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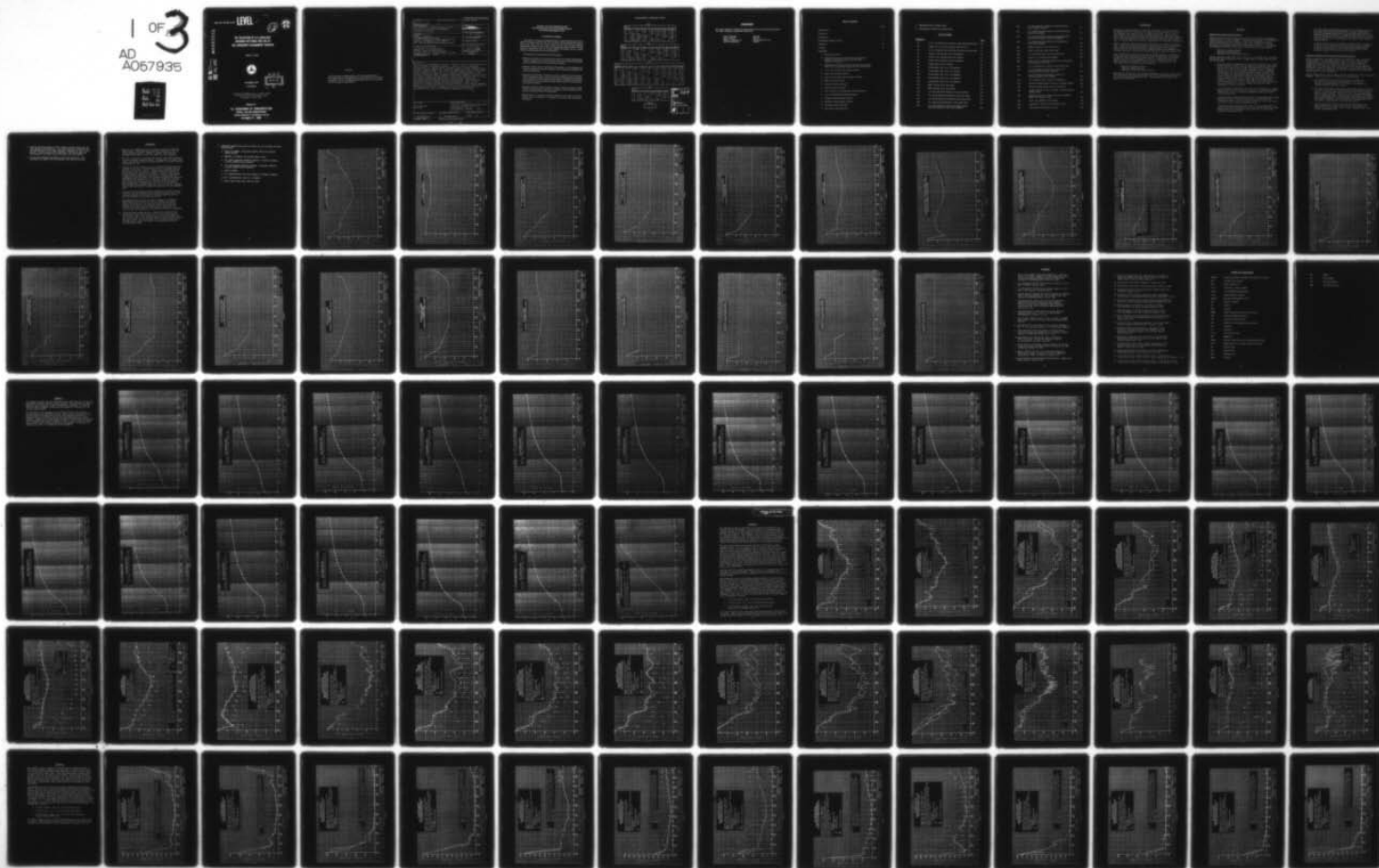
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THE SELECTION OF ILS LOCALIZER ANTENNA PATTERNS FOR USE IN THE --ETC(U)
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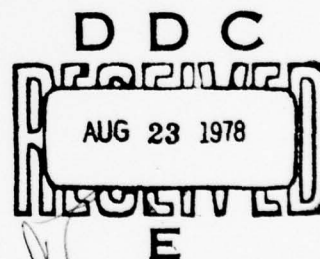
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THE SELECTION OF ILS LOCALIZER ANTENNA PATTERNS FOR USE IN THE FREQUENCY ASSIGNMENT PROCESS

Robert D. Smith



SEPTEMBER 1978

Final Report

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20580

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Technical Report Documentation Page

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16. Abstract The frequency assignment process is meant to insure interference-free service within the service volume. This is done by choosing frequencies in a manner which provides certain minimum cochannel and adjacent channel desired to undesired signal ratios at critical points of the service volume. One of the factors which affects a station's signal strength in space is its horizontal antenna pattern. ILS localizer antennas have undergone significant changes in recent years. In order to reduce siting effects, antenna patterns have evolved from the nearly omnidirectional 8-loop to the highly directional traveling wave and log periodic dipole antennas. The horizontal localizer antenna pattern now has a substantial effect on the separation required between localizer stations. This report compares measured and theoretical data with FAA antenna pattern specifications. For each antenna type, a single horizontal antenna pattern is recommended for use in the frequency assignment process.		
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**FEDERAL AVIATION ADMINISTRATION
SYSTEMS RESEARCH AND DEVELOPMENT SERVICE
SPECTRUM MANAGEMENT STAFF**

STATEMENT OF MISSION

The mission of the Spectrum Management Staff is to assist the Department of State, Office of Telecommunications Policy, and the Federal Communications Commission in assuring the FAA's and the nation's aviation interests with sufficient protected electromagnetic telecommunications resources throughout the world to provide for the safe conduct of aeronautical flight by fostering effective and efficient use of a natural resource--the electromagnetic radio-frequency spectrum.

This objective is achieved through the following services:

- Planning and defending the acquisition and retention of sufficient radio-frequency spectrum to support the aeronautical interests of the nation, at home and abroad, and spectrum standardization for the world's aviation community.
- Providing research, analysis, engineering, and evaluation in the development of spectrum related policy, planning, standards, criteria, measurement equipment, and measurement techniques.
- Conducting electromagnetic compatibility analyses to determine intra/inter-system viability and design parameters, to assure certification of adequate spectrum to support system operational use and projected growth patterns, to defend the aeronautical services spectrum from encroachment by others, and to provide for the efficient use of the aeronautical spectrum.
- Developing automated frequency-selection computer programs/routines to provide frequency planning, frequency assignment, and spectrum analysis capabilities in the spectrum supporting the National Airspace System.
- Providing spectrum management consultation, assistance, and guidance to all aviation interests, users, and providers of equipment and services, both national and international.

ENGLISH/METRIC CONVERSION FACTORS

LENGTH

To From	cm	m	km	in	ft	mi	nmi
cm	1	0.01	1x10 ⁻⁵	0.3937	0.0328	6.21x10 ⁻⁶	5.39x10 ⁻⁶
m	100	1	0.001	39.37	3.281	0.0006	0.0005
km	100,000	1000	1	39370	3281	0.6214	0.5395
in	2.540	0.0254	2.54x10 ⁻⁵	1	0.0833	1.58x10 ⁻⁵	1.37x10 ⁻⁵
ft	30.48	0.3048	3.05x10 ⁻⁴	12	1	1.89x10 ⁻⁴	1.64x10 ⁻⁴
mi	160,900	1609	1.609	63360	5280	1	0.8688
nmi	185,200	1852	1.852	72930	6076	1.151	1

AREA

To From	cm ²	m ²	km ²	in ²	ft ²	mi ²	nmi ²
cm ²	1	0.0001	1x10 ⁻¹⁰	0.1550	0.0011	3.86x10 ⁻¹¹	5.11x10 ⁻¹¹
m ²	10,000	1	1x10 ⁻⁶	1550	10.76	3.86x10 ⁻⁷	5.11x10 ⁻⁷
km ²	1x10 ¹⁰	1x10 ⁶	1	1.55x10 ⁹	1.08x10 ⁷	0.3861	0.2914
in ²	6.452	0.0006	6.45x10 ⁻¹⁰	1	0.0069	2.49x10 ⁻¹⁰	1.88x10 ⁻¹⁰
ft ²	929.0	0.0929	9.29x10 ⁻⁸	144	1	3.59x10 ⁻⁸	2.71x10 ⁻⁸
mi ²	2.59x10 ¹⁰	2.59x10 ⁶	2.590	4.01x10 ⁹	2.79x10 ⁷	1	0.7548
nmi ²	3.43x10 ¹⁰	3.43x10 ⁶	3.432	5.31x10 ⁹	3.70x10 ⁷	1.325	1

VOLUME

To From	cm ³	liter	m ³	in ³	ft ³	yd ³	fl. oz.	fl. pt.	fl. qt.	gal.
cm ³	1	0.001	1x10 ⁻⁶	0.0610	3.53x10 ⁻⁵	1.31x10 ⁻⁶	0.0338	0.0021	0.0010	0.0002
liter	1000	1	0.001	61.02	0.0353	0.0013	33.81	2.113	1.057	0.2642
m ³	1x10 ⁶	1000	1	61,000	35.31	1.308	33,800	2113	1057	264.2
in ³	16.39	0.0163	1.64x10 ⁻⁵	1	0.0006	2.14x10 ⁻⁵	0.5541	0.0346	2113	0.0043
ft ³	28,300	28.32	0.0283	1728	1	0.0370	957.5	59.84	0.0173	7.481
yd ³	765,000	764.5	0.7646	46700	27	1	25900	1616	807.9	202.0
fl. oz.	29.57	0.2957	2.96x10 ⁻⁵	1.805	0.0010	3.87x10 ⁻⁵	1	0.0625	0.0312	0.0078
fl. pt.	473.2	0.4732	0.0005	28.88	0.0167	0.0006	16	1	0.5000	0.1250
fl. qt.	948.4	0.9463	0.0009	57.75	0.0334	0.0012	32	2	1	0.2500
gal.	3785	3.785	0.0038	231.0	0.1337	0.0050	128	8	4	1

MASS

To From	g	kg	oz	lb	ton
g	1	0.001	0.0353	0.0022	1.10x10 ⁻⁶
kg	1000	1	35.27	2.205	0.0011
oz	28.35	0.0283	1	0.0625	3.12x10 ⁻⁵
lb	453.6	0.4536	16	1	0.0005
ton	907,000	907.2	32,000	2000	1

TEMPERATURE

$$^{\circ}\text{F} = 5/9 (^{\circ}\text{C} - 32)$$

$$^{\circ}\text{C} = 9/5 (^{\circ}\text{F}) + 32$$

ADDITIONAL BY	
BY	White Section <input checked="" type="checkbox"/>
DO	Buff Section <input type="checkbox"/>
UNANNOUNCED <input type="checkbox"/>	
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AFS-530
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ANW-450

TABLE OF CONTENTS

	PAGE
Introduction	1
Discussion	2
Conclusions	5
Recommended Antenna Patterns	7
References	28
Acronyms	30
Appendixes	
A. Calibration Curves	
B. Comparison of Measured AGC Patterns and Spectrum Analyzer Patterns for Various Antenna Types (Plotted in Decibels)	
C. Comparison of Measured AGC Data and Spectrum Analyzer Data for Various Antenna Types (Plotted in Microvolts)	
D. A.I.L. Type 55 Twin Tee Antenna Patterns	
E. Eight Loop Antenna Patterns	
F. Wilcox Log Periodic Dipole Antenna Patterns	
G. MRN-7 Antenna Patterns	
H. Parabolic Antenna Patterns	
I. STAN-37 Antenna Patterns	
J. A.M.C. and T.I. Traveling Wave Antenna Patterns	
K. A.P.C. Traveling Wave Antenna Patterns	
L. Standard V-Ring Antenna Patterns	
M. Modified V-Ring Antenna Patterns	
N. Waveguide Antenna Patterns	
O. FAA Antenna Specifications	

P. Additional Wilcox Antenna Types

Q. Photographs of Different Antenna Types

LIST OF FIGURES

<u>FIGURE NO.</u>		<u>PAGE</u>
Q1	A.I.L. 9 Element Twin Tee Array, Type 352110 (Side View)	Q2
Q2	Single A.I.L. Twin Tee Element, Type 352111-1	Q3
Q3	A.I.L. 9 Element Twin Tee Array (Top View and Side View)	Q4
Q4	Wilcox L.P.D. Antenna Array (8 elements)	Q5
Q5	Wilcox L.P.D. Antenna Array (14 elements)	Q5
Q6	Wilcox L.P.D. Antenna Array (8 elements)	Q6
Q7	Single Wilcox L.P.D. Element	Q6
Q8	Wilcox Model 1203 L.P.D. (6 elements)	Q7
Q9	Wilcox Model 1203 L.P.D. (6 elements)	Q7
Q10	Wilcox Model 1261 L.P.D. (6 elements)	Q8
Q11	Wilcox Model 1261 L.P.D. (6 elements)	Q8
Q12	Wilcox Model 1260 L.P.D. (4 elements)	Q9
Q13	MRN-7 Antenna Array (Top View)	Q10
Q14	MRN-7 Antenna Array (Side View)	Q11
Q15	T.I. Wide Aperature Parabolic Array (Top View)	Q12
Q16	T.I. Narrow Aperature Parabolic Array (Top View)	Q12
Q17	T.I. Narrow Aperature Parabolic Array (Side View)	Q13
Q18	T.I. Wide Aperature Parabolic Array (Side View)	Q14
Q19	T.I. Wide Aperature Parabolic Antenna, Course Array and Clearance Array (with radomes)	Q14

Q20	T.I. Wide Aperature Parabolic Antenna, Clearance Array (without radomes)	Q15
Q21	T.I. Narrow Aperature Parabolic Antenna, Clearance Array (with radomes)	Q15
Q22	T.I. Narrow Aperature Parabolic Antenna, Parabolic Reflector and Course Array (with Radomes)	Q16
Q23	T.I. Narrow Aperature Parabolic Antenna, Course Array (with radomes)	Q16
Q24	STAN-37 Localizer Array (Front View)	Q17
Q25	STAN-37 Localizer Array (Back View)	Q17
Q26	T.I. Traveling Wave Array, 14/6 (Top View)	Q18
Q27	Single T.I. Traveling Wave Element	Q18
Q28	A.M.C. and T.I. numbering systems for the Treveling Wave Antenna Array (14/6)	Q19
Q29	T.I. Traveling Wave Localizer Array (Rear View)	Q20
Q30	T.I. Traveling Wave Localizer, close up of Antenna Elements (without radomes)	Q21
Q31	T.I. Traveling Wave Localizer, close up of Antenna Elements (with radomes)	Q21
Q32	T.I. Traveling Wave Localizer (8 elements)	Q22
Q33	Standard V-Ring Antenna, close up of V-Ring Elements	Q22
Q34	Standard V-Ring Antenna Array (15 elements)	Q23
Q35	Antenna Spacing for the 12 element V-Ring Localizer Antenna Array	Q23
Q36	Waveguide Localizer Course Array with a Standard Eight Loop Clearance Array	Q24
Q37	Cubic Corp. VORLOC II LDA Antenna	Q24
Q38	Experimental Slotted Cable Localizer Array	Q25
Q39	Slotted Cable Localizer, close up	Q25

INTRODUCTION

In the past, standard distance separations of cochannel ILS have been based on antenna patterns of the older, more omnidirectional facilities. Most of the antennas being installed today are highly directional. In the past, we made conservative estimates of the separations required for these facilities on the basis of theoretical patterns, FAA specifications, and limited empirical data. Since the agency is continuing to install 100 kHz facilities in areas that are already congested, we can no longer afford to be extremely conservative.

Since a search for antenna data had provided only a small amount of empirical data, it was decided that data should be gathered for a sample of each antenna type. Under an intra-agency agreement, this information was gathered by Flight Inspection National Field Office (FINFO) personnel from Oklahoma City. An effort was made to obtain three antenna patterns of each major antenna type.

Data reduction and analysis has been done by ARD-60 personnel. In addition to the data taken in January, further reduction has been done on information obtained at other times and from other sources. Of particular note is the further reduction of data contained in Report No. FAA-RD-75-165 II, data which was also taken by FINFO. Wherever possible, comparisons have been made between the following types of information:

- Theoretical Antenna Patterns.
- Empirical Antenna Patterns.
- Applicable FAA Antenna Specifications.

Data for each antenna type is included in appendixes at the rear of this report. On the basis of this data, antenna patterns of each type have been chosen for use in the frequency assignment process. These patterns are shown in the conclusion of the report.

DISCUSSION

Rationale For Antenna Pattern Choices

Taking horizontal antenna patterns into account, in the frequency assignment process, will allow closer cochannel siting in some situations. Less separation could potentially cause interference. Since radio navigation is a safety service, interference must be avoided at all cost. With this in mind, we have taken a conservative approach in choosing antenna patterns. In examining the information available, three types of antenna data have been compared:

- Theoretical Antenna Patterns
- Empirical Antenna Patterns
- Applicable FAA Antenna Specifications

Ideally, agreement among these types of data, for each antenna type, is desired. Practically, this is seldom the case. In many cases, all three types of data are not available.

- If no FAA antenna specification was found to be applicable for a given antenna type and if there was good comparison between the theoretical data and the measured data, we chose the theoretical pattern as the pattern to be used in the frequency assignment process. Examples of this can be seen in the patterns chosen for the A.I.L. Twin Tee, the Waveguide, the eight loop and the MRN-7 antenna patterns. The pattern chosen for the modified V-Ring is an exception to this rule. A more conservative pattern was picked for this antenna type for several reasons. First, only a small amount of measured data was available. Second, this measured data came from the same source as the theoretical data. Third, since only two of this antenna type have been installed, it should not matter very much if we are conservative in how we treat it.
- If no FAA antenna specification was found to be applicable for a given antenna type and if the theoretical data and the measured data did not compare well, we chose a frequency assignment pattern on the basis of the measured data.
- If an FAA antenna specification was found to be applicable for a given antenna type and if both the theoretical data and measured data compared well with it, we would choose the specification as the pattern to be used in the frequency assignment process.
- If an FAA antenna specification was found to be applicable and if it compared well with the measured data but not with the theoretical data, we would choose the specification as the pattern to be used in the frequency assignment process.

- If an FAA antenna specification was found to be applicable and it did not compare well with the measured data, we chose a conservative frequency assignment pattern based on a carefully chosen mixture of specification and measured data. Examples of this can be seen in the frequency assignment patterns chosen for the A.M.C. and T.I. traveling wave antenna, the A.P.C. traveling wave, the Wilcox L.P.D., and the standard V-Ring.
- If theoretical data was only available for some portion of a pattern, we tried to get as much measured data as possible before picking a conservative pattern for use in the frequency assignment process. In the case of the STAN-37, and the Type 3(5/3) and Type 4(4/3) parabolic antennas, we see the need for more data.

Differences Between AGC And Spectrum Analyzer Measurements

Graphs in Appendix C show comparisons of data obtained by these two methods of measurement. Some substantial differences can be seen. Several major reasons account for these discrepancies. First, the two equipment are calibrated differently. The spectrum analyzer was tuned for the peaks of signals while the localizer receiver would be expected to flatten peaks and valleys in the signal. Second, the two equipment do not have the same response to a given signal. AGC averaging, receiver lag, and other signal processing factors result in these differences.

Several things could be done to improve the data comparison in future measurement programs. Among the ideas to be considered are the following:

1. Put a localizer test set on the aircraft and calibrate the localizer receiver and the spectrum analyzer just before and just after measurement of each facility. Average the two calibrations where differences exist.
2. Use a spectrum analyzer with variable persistence to store a number of traces. Since the peak spectrum analyzer measurement moved up and down by 10 dB in very short periods of time, this would allow some form of signal averaging. Taking a picture of the spectrum analyzer data is recommended since it would provide a permanent record which could be double-checked in case there were major discrepancies between measurement techniques. The disadvantage of this approach is that it requires a large amount of very fast camera work.
3. Expand the AGC trace and use calibrated attenuation pads to get better readability at higher signal levels. This amounts to shifting the receiver input level to a more responsive part of the receiver calibration curve.

4. Both the spectrum analyzer and the localizer receiver should use the same antenna as was done here. Line losses should be calibrated from the antenna output to the signal splitter, something not done in this project. This no easy job in a Sabreliner. The access panel near the antenna is very small and all the cables are tied together.
5. Consider the modulation percentage of the ground facility. This percentage will affect the peak reading of the spectrum analyzer.

CONCLUSIONS

1. There are vast differences in the horizontal patterns of different antenna types. These differences should be considered in the frequency assignment process. Changes in antenna types should be considered by the FMO's, in the same manner as a new assignment.
2. The A.M.C. and the T.I. traveling wave antenna arrays have essentially the same horizontal antenna patterns. In making and recording assignments, care should be taken in indicating which of the several antenna combinations is used.
3. Contrary to popular opinion, there are differences between radiation patterns of the A.P.C. traveling wave, the T.I. traveling wave, and the Wilcox log periodic dipole. Although these differences do not appear large, they are expected to make a difference in the "back to back cochannel spacing" of two antennas. "Back to back spacing" is defined as the separation required for two antennas which are pointing away from each other. The smaller the back course radiation, the smaller this distance can be. The major change that is being made is that this distance is now a function of antenna types and some combinations of antenna types will allow it to be smaller. By discriminately changing antenna types at the edge of a congested area, it may be possible to assign more frequencies in that congested area.
4. In the process of gathering measured antenna data, we used facility records to see what locations had the different antenna types. This experience pointed out that current facility records are not 100 per cent dependable in the data they provide.
5. Recommended antenna patterns are shown in Figures 1 through 19. These patterns are intended as tools for avoiding interference between ILS localizers. In some cases, these are not the best patterns to use as tools for avoiding interference between ILS localizers and other types of radio services. Should the need arise to make such an analysis, discussion with ARD-60 is recommended.
6. In specifying an antenna pattern, it makes sense to specify the directivity and the front to back ratio for an elevation angle of zero degrees. This allows the pattern to be measured without the use of an aircraft. At an elevation angle of several degrees, however, the front to back ratio and portions of the antenna pattern (50 to 180 degrees off course) are likely to be substantially different for some antenna types.

7. Additional measured data would be helpful for the following localizer antenna types:

- a. Wilcox 14 element, log periodic dipole, MK-I self clearing array, FA-9359.
- b. GRN-29V, 14 elements, log periodic dipole array.
- c. T.I. narrow aperture parabolic antenna, 5 clearance elements, 3 course elements with a parabola.
- d. T.I. wide aperture parabolic antenna, 4 clearance elements, 3 course elements with a parabola.
- e. Stan-37 antenna.
- f. T.I. traveling wave, 20 course elements, 8 clearance elements.
- g. A.P.C. traveling wave, type II, 14 elements
- h. Wilcox models 1201, 1203, 1204, and 1261.

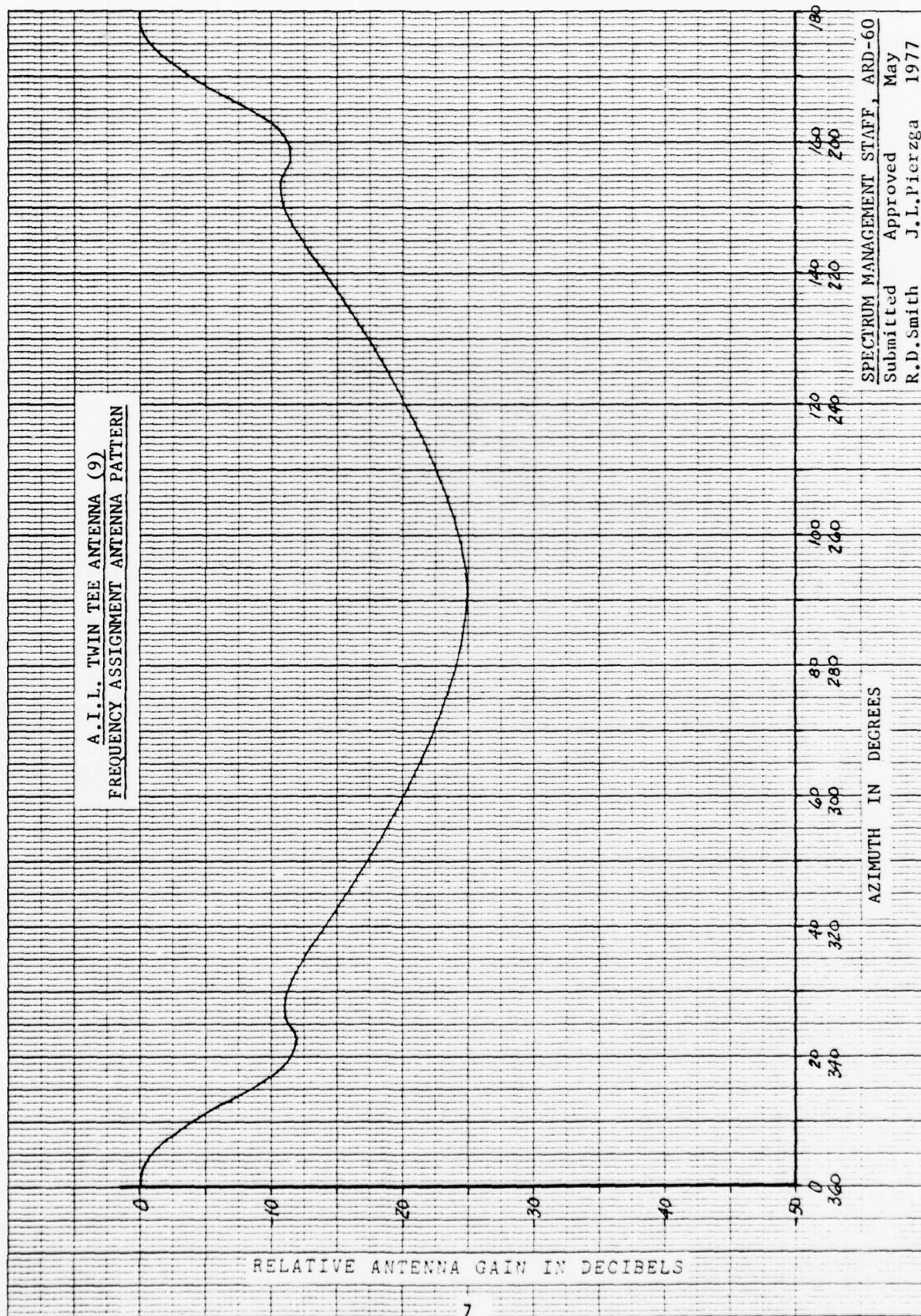


FIGURE 1

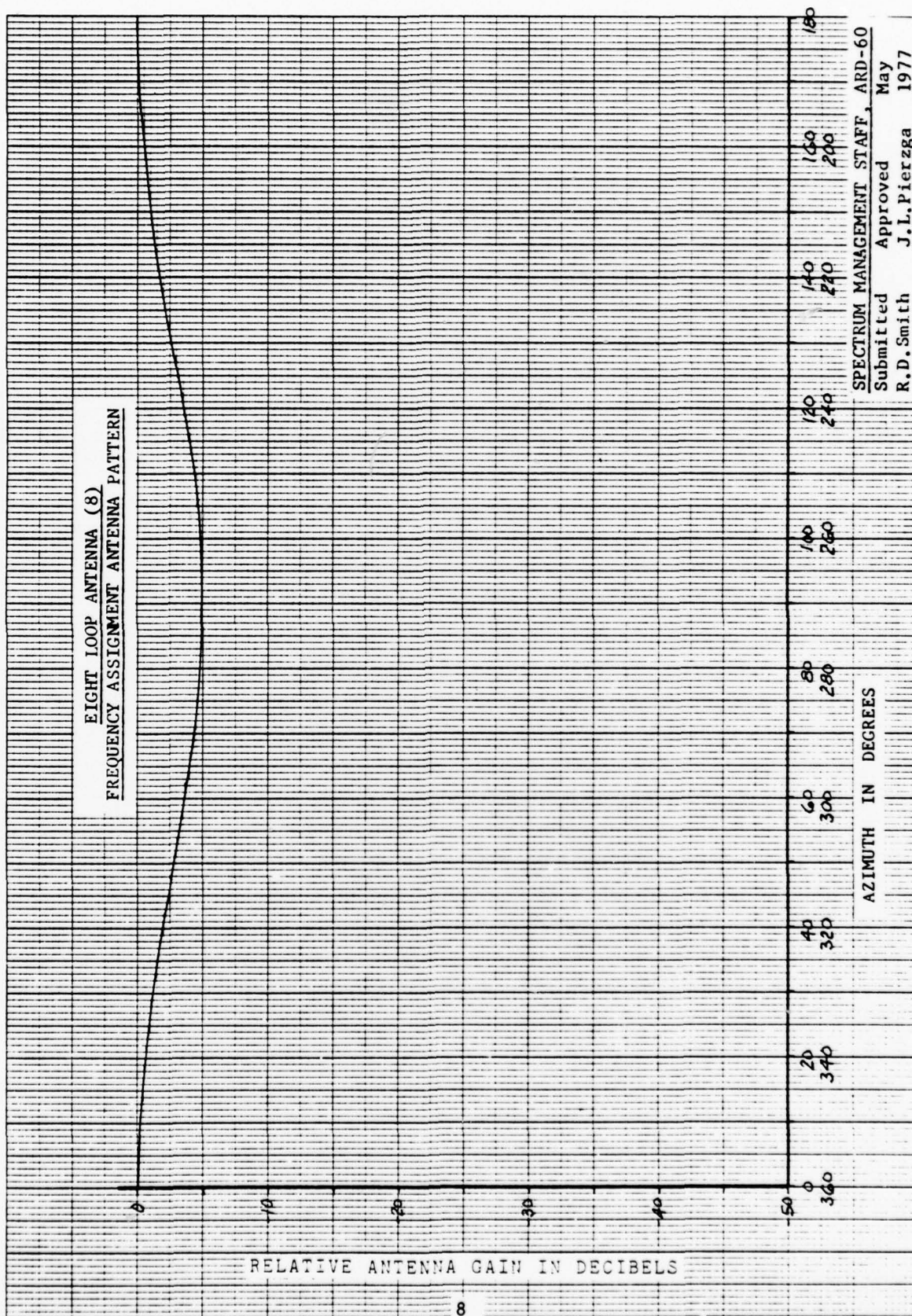


FIGURE 2

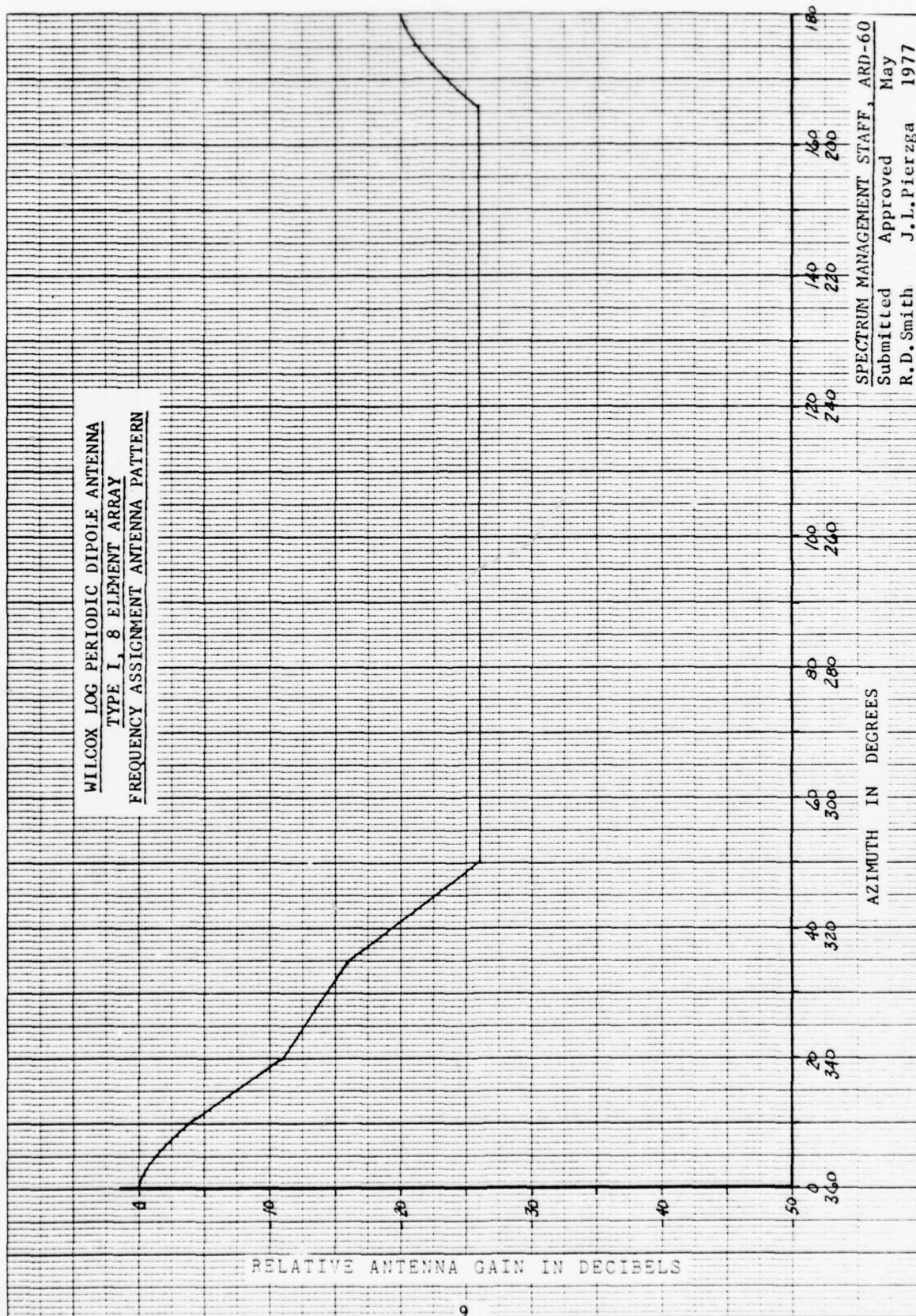


FIGURE 3

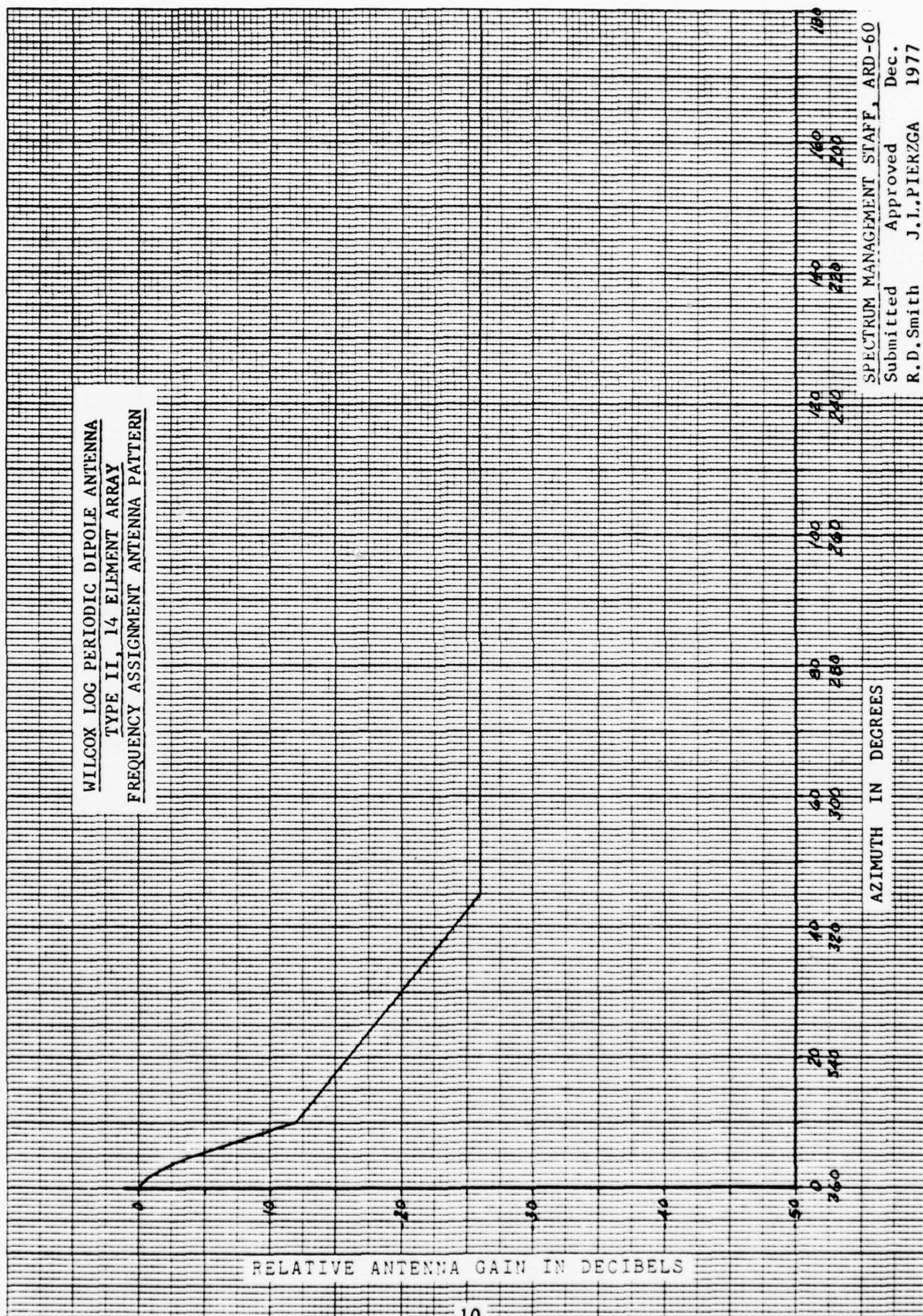


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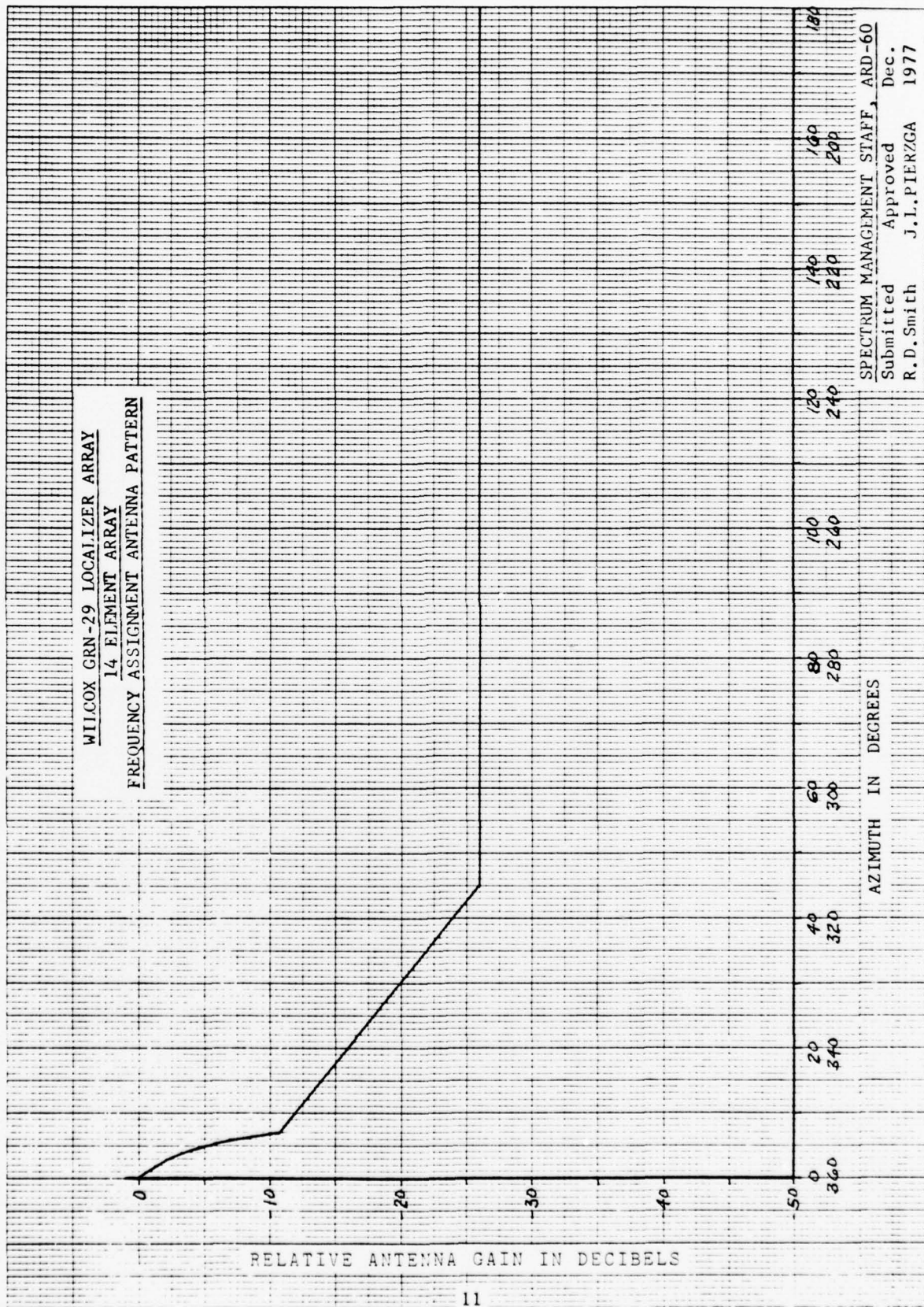


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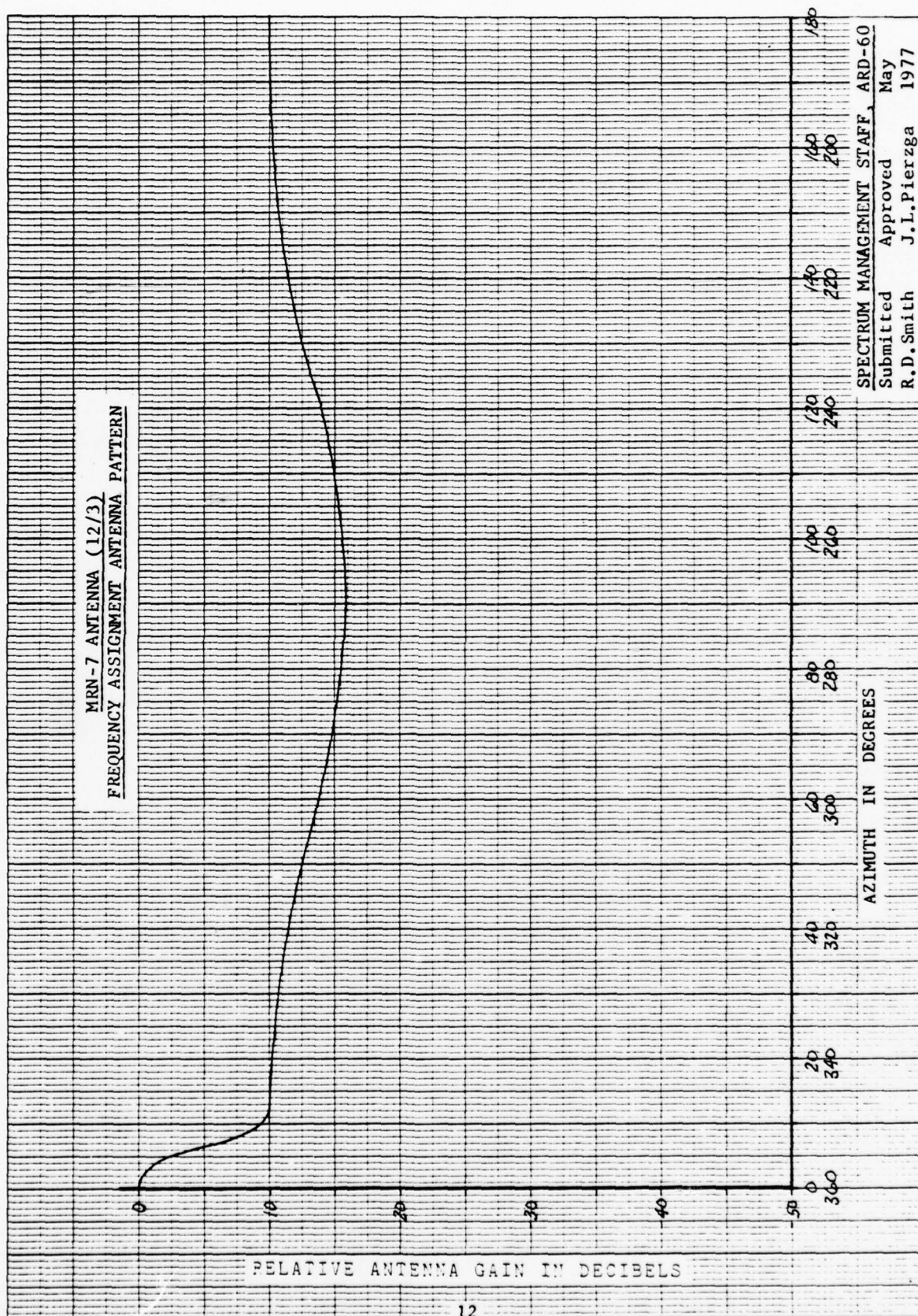


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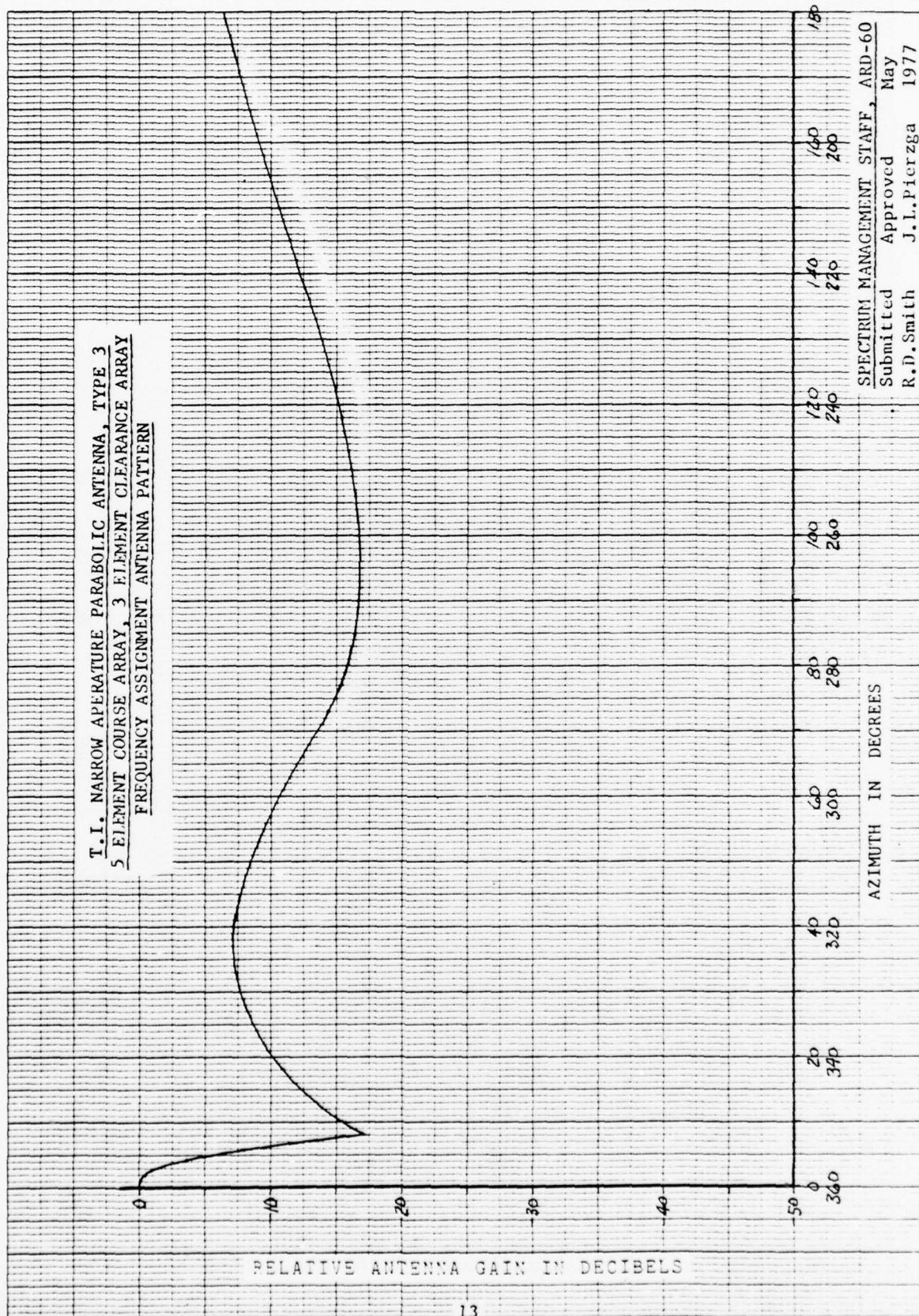


FIGURE 7

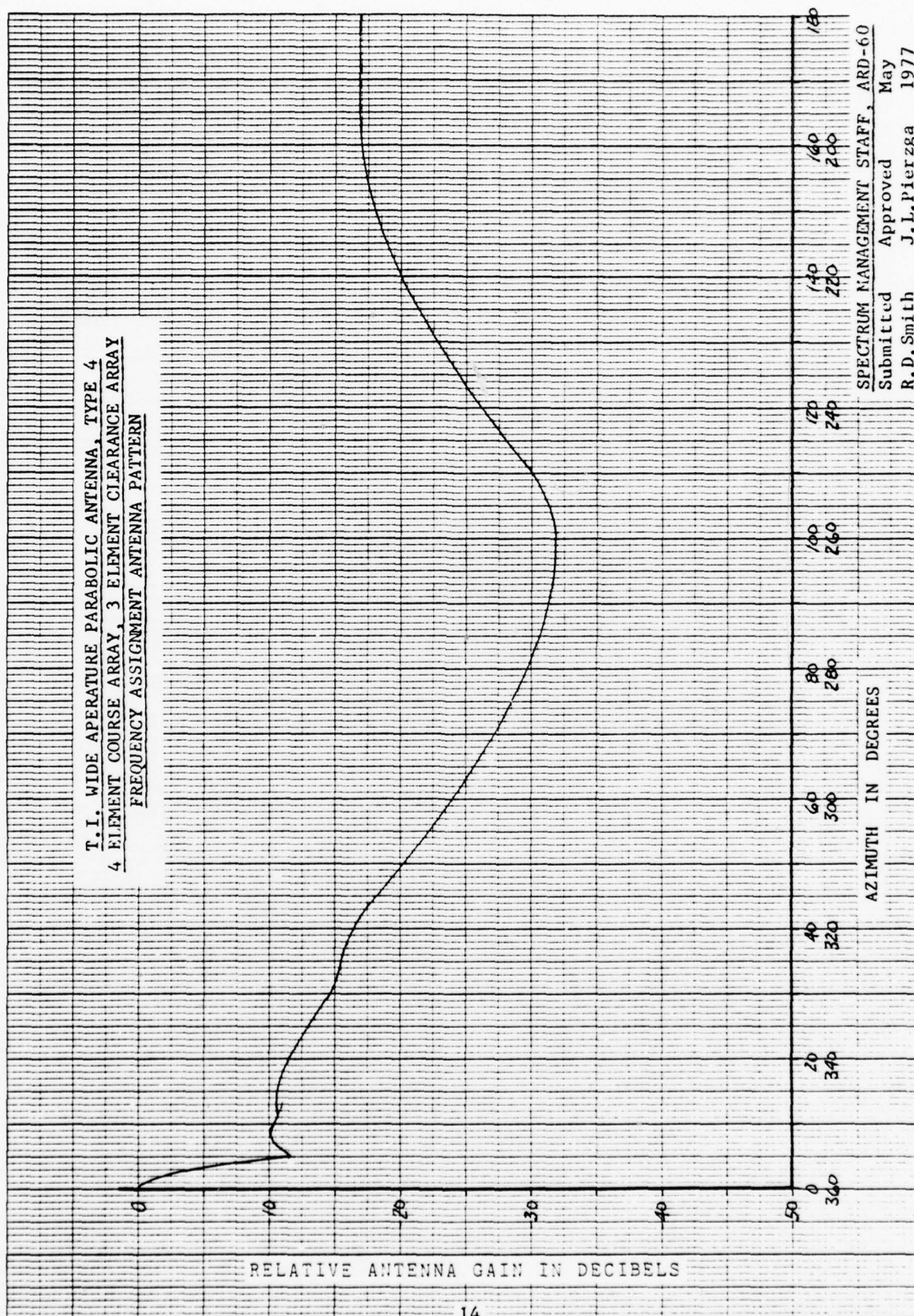


FIGURE 8

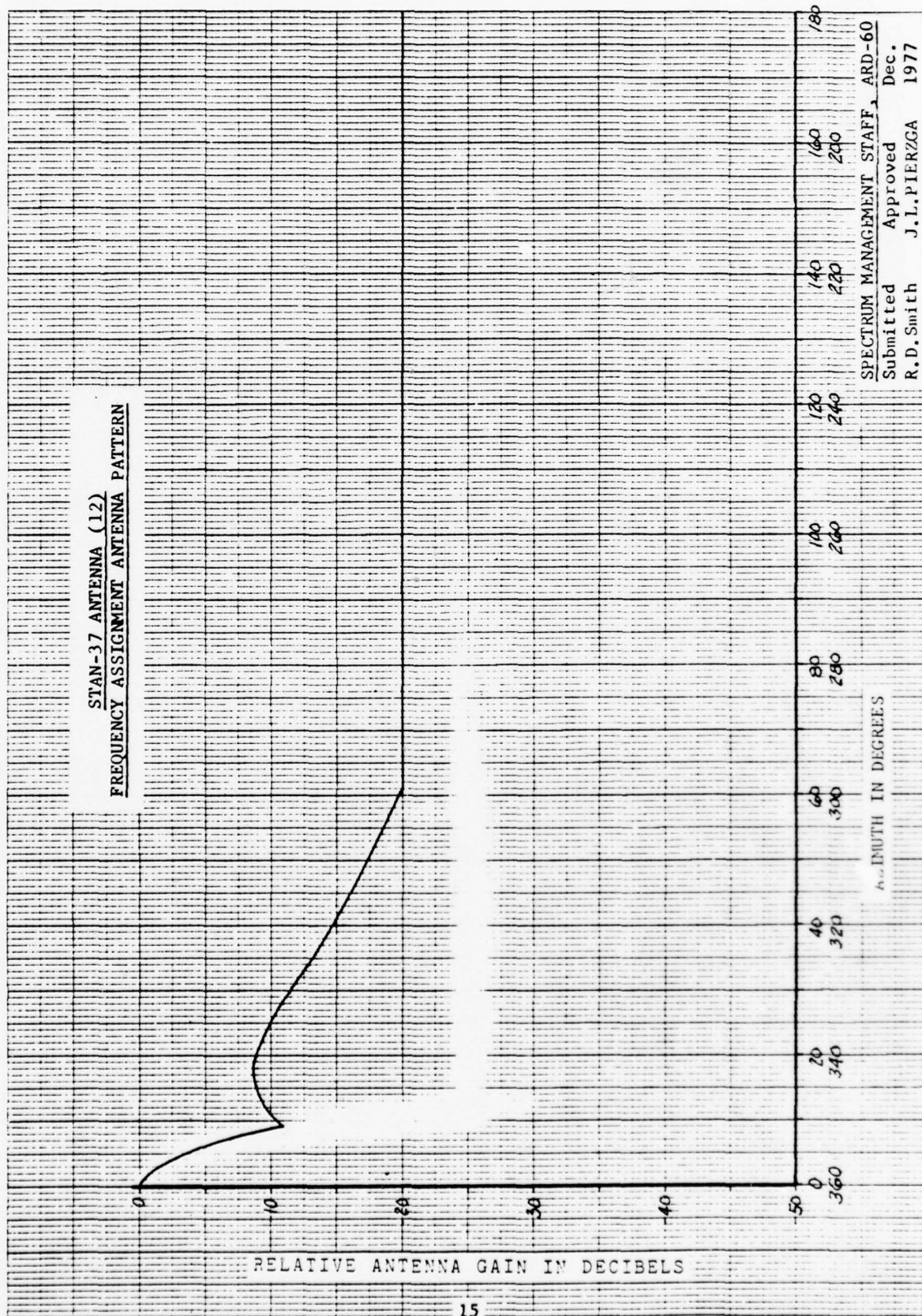
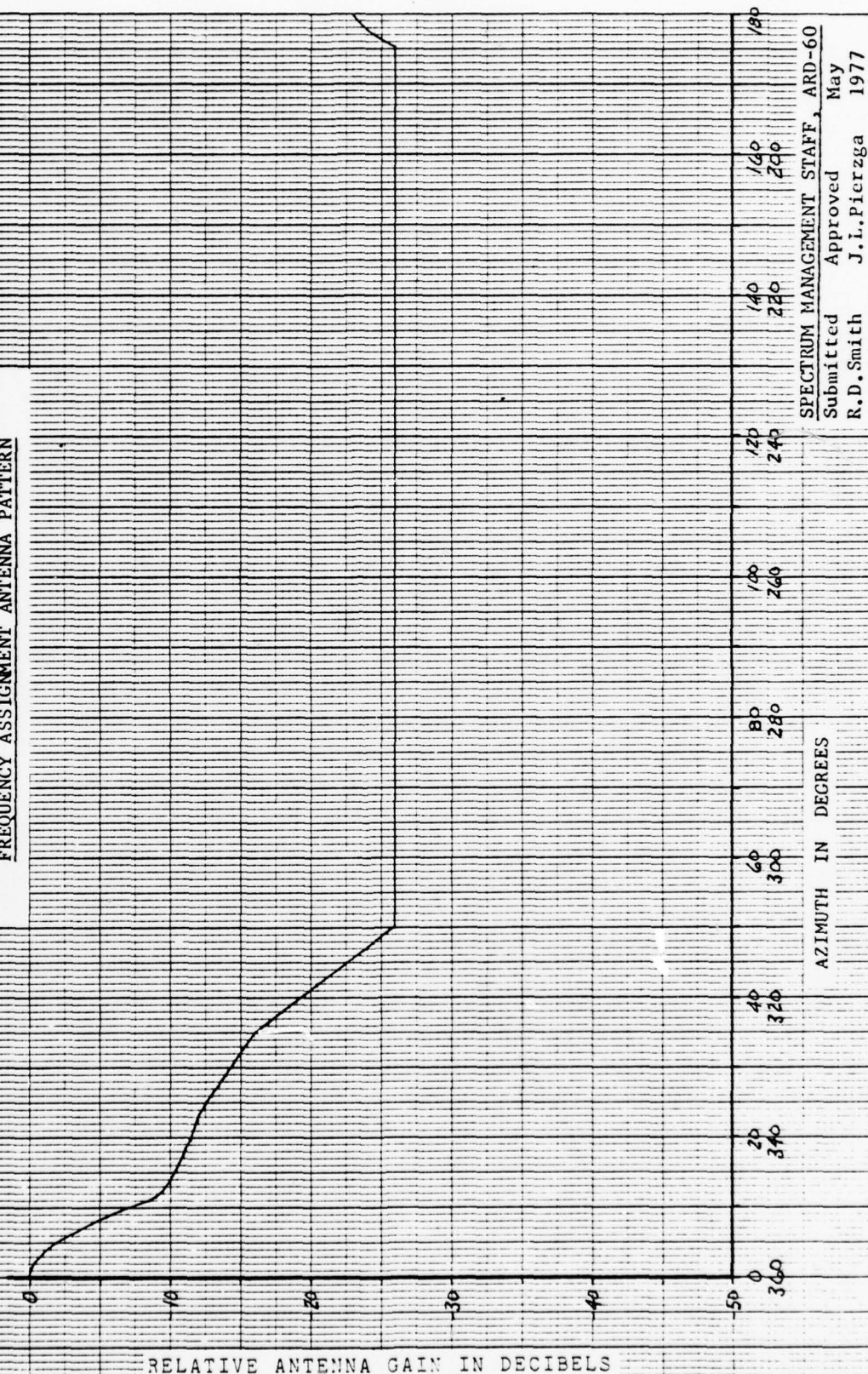


FIGURE 9

A.M.C. AND T.I. TRAVELING WAVE ANTENNA (14/6)
 FREQUENCY ASSIGNMENT ANTENNA PATTERN



SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D. Smith
 Approved J.L. Pierzga
 May 1977

FIGURE 10

A.M.C. AND T.I. TRAVELING WAVE ANTENNA
8 ELEMENT SELF-CLEARING ARRAY
FREQUENCY ASSIGNMENT ANTENNA PATTERN



FIGURE 11

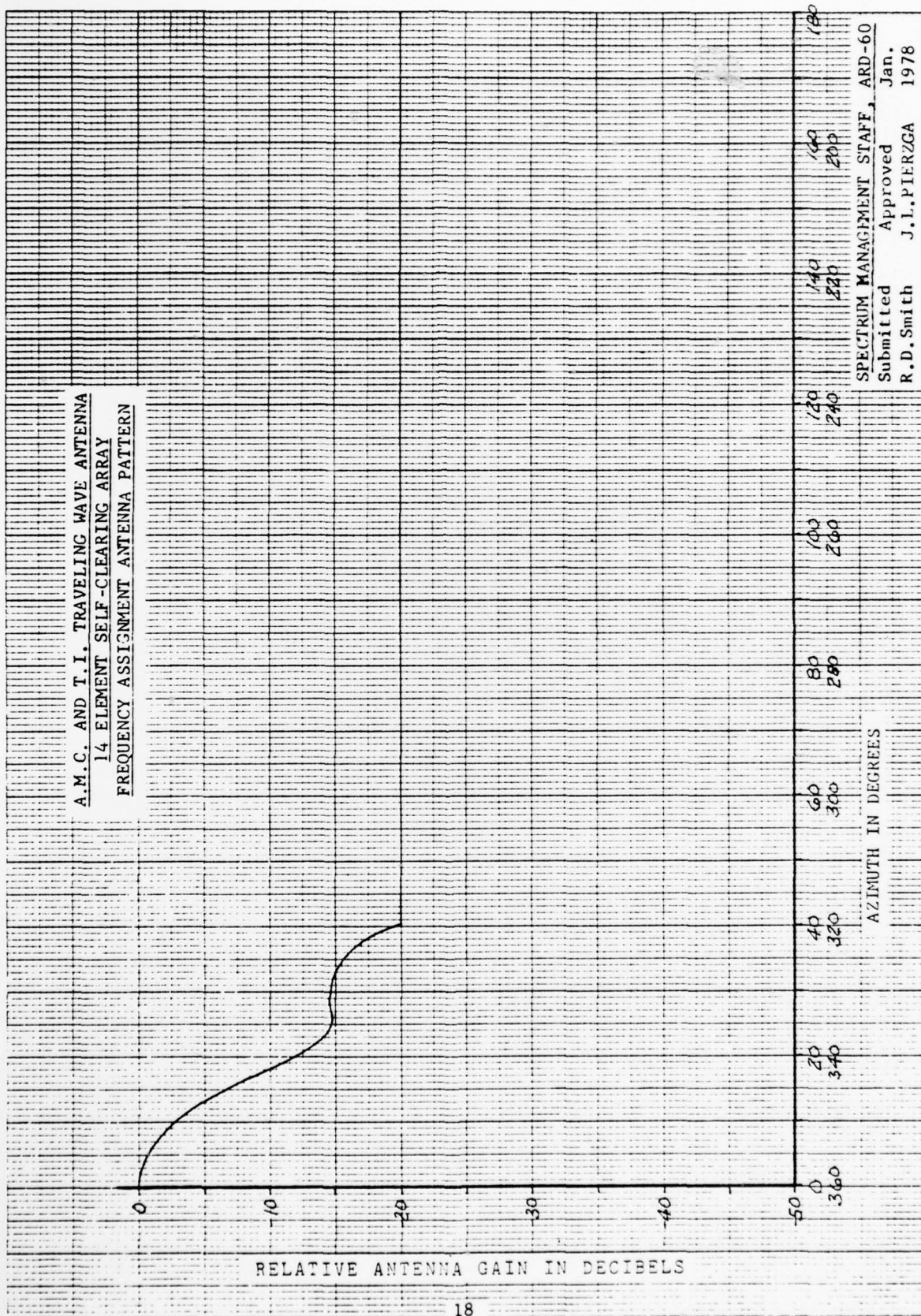


FIGURE 12

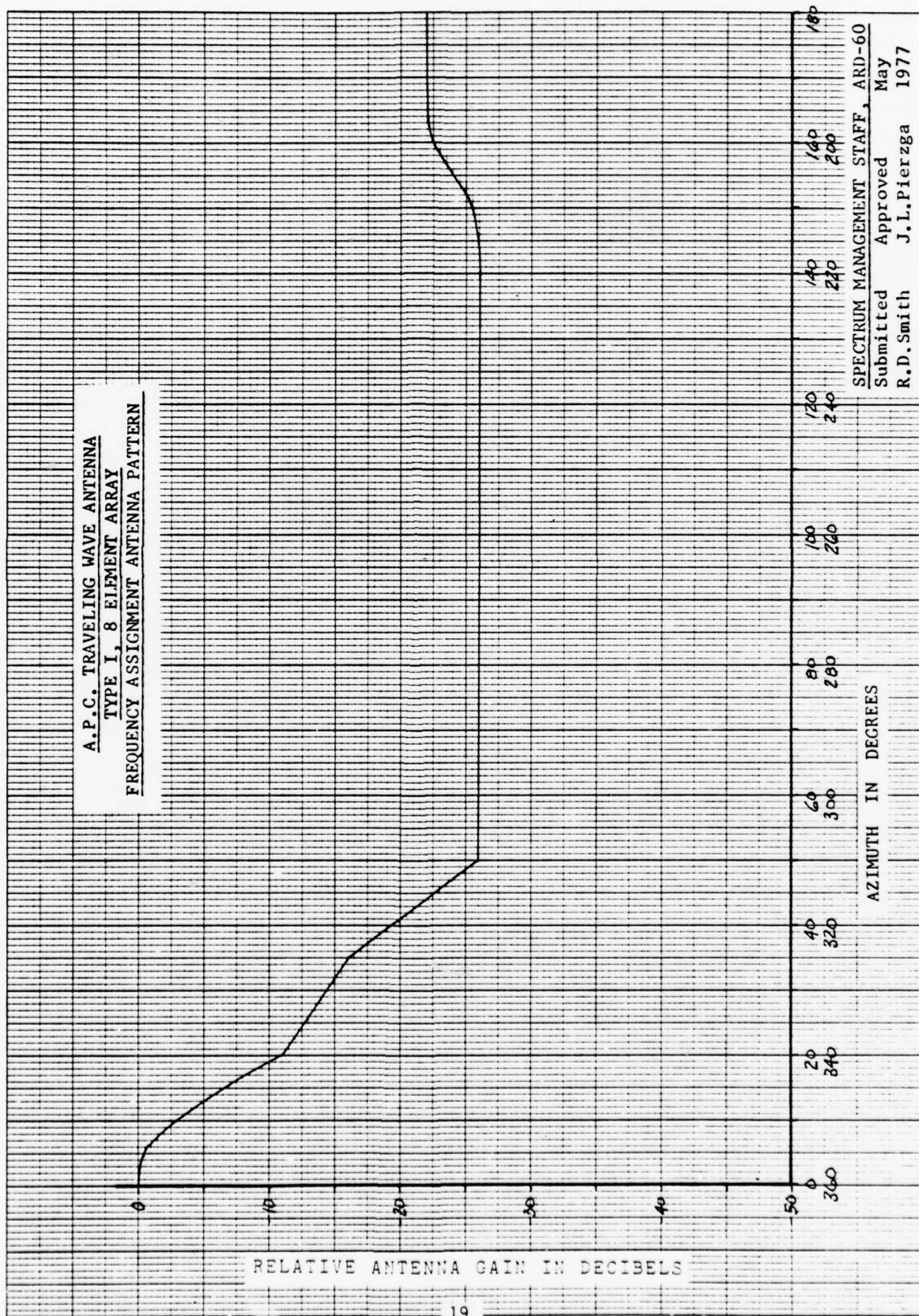
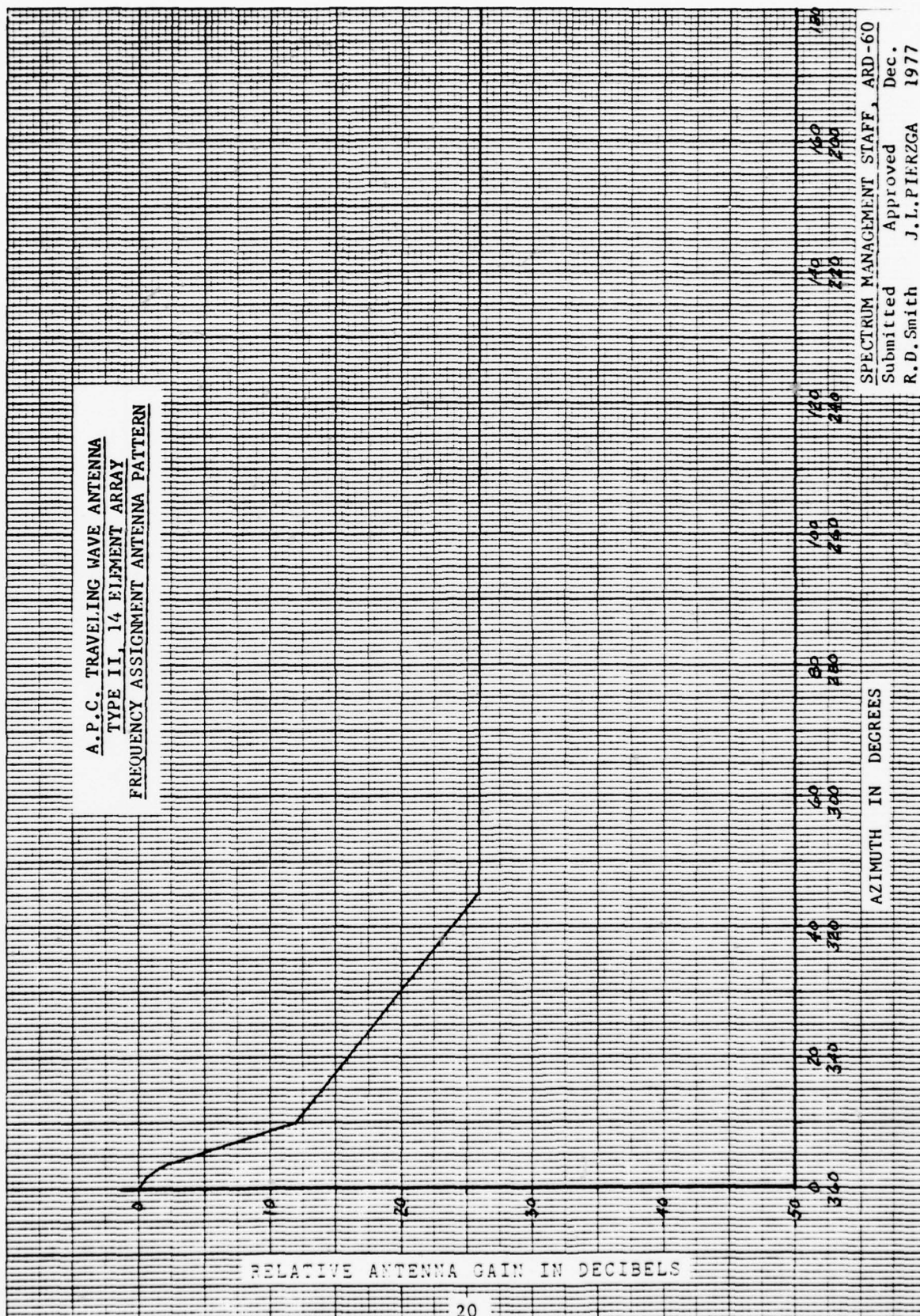


FIGURE 13

A.P.C. TRAVELING WAVE ANTENNA
TYPE II, 14 ELEMENT ARRAY
FREQUENCY ASSIGNMENT ANTENNA PATTERN



SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D. Smith
 Approved J.L. PIERZGA
 Dec. 1977

FIGURE 14

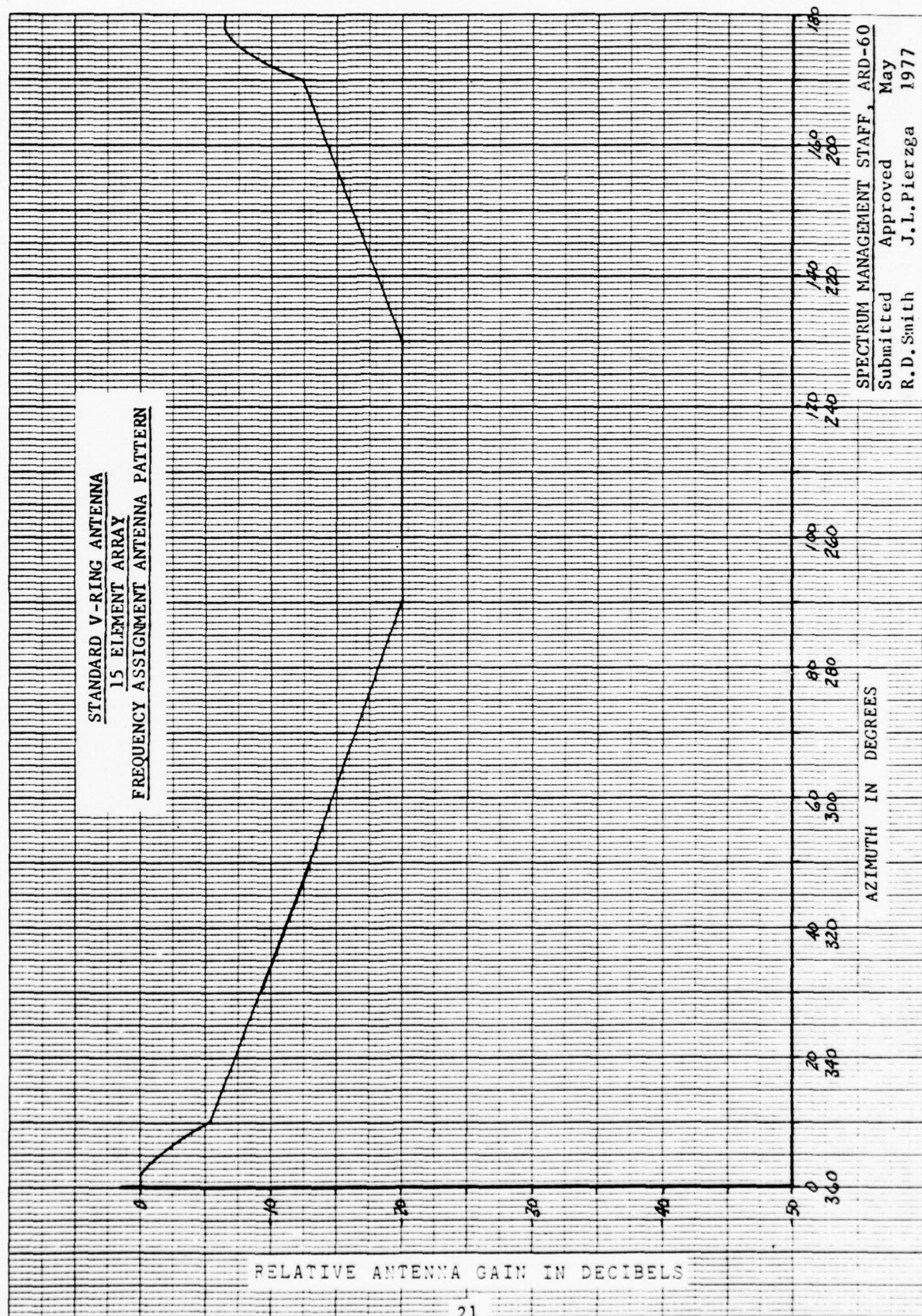


FIGURE 15

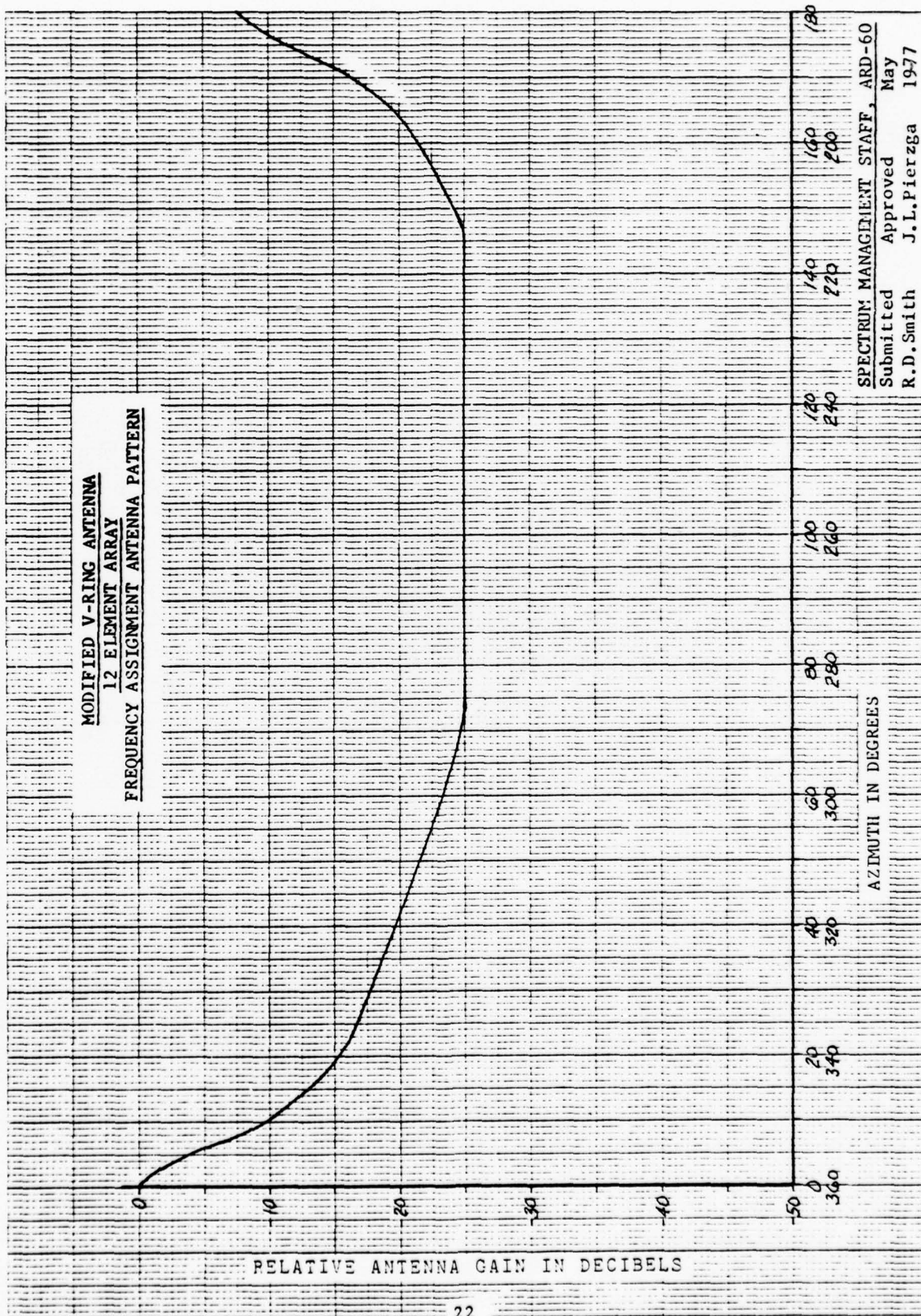


FIGURE 16

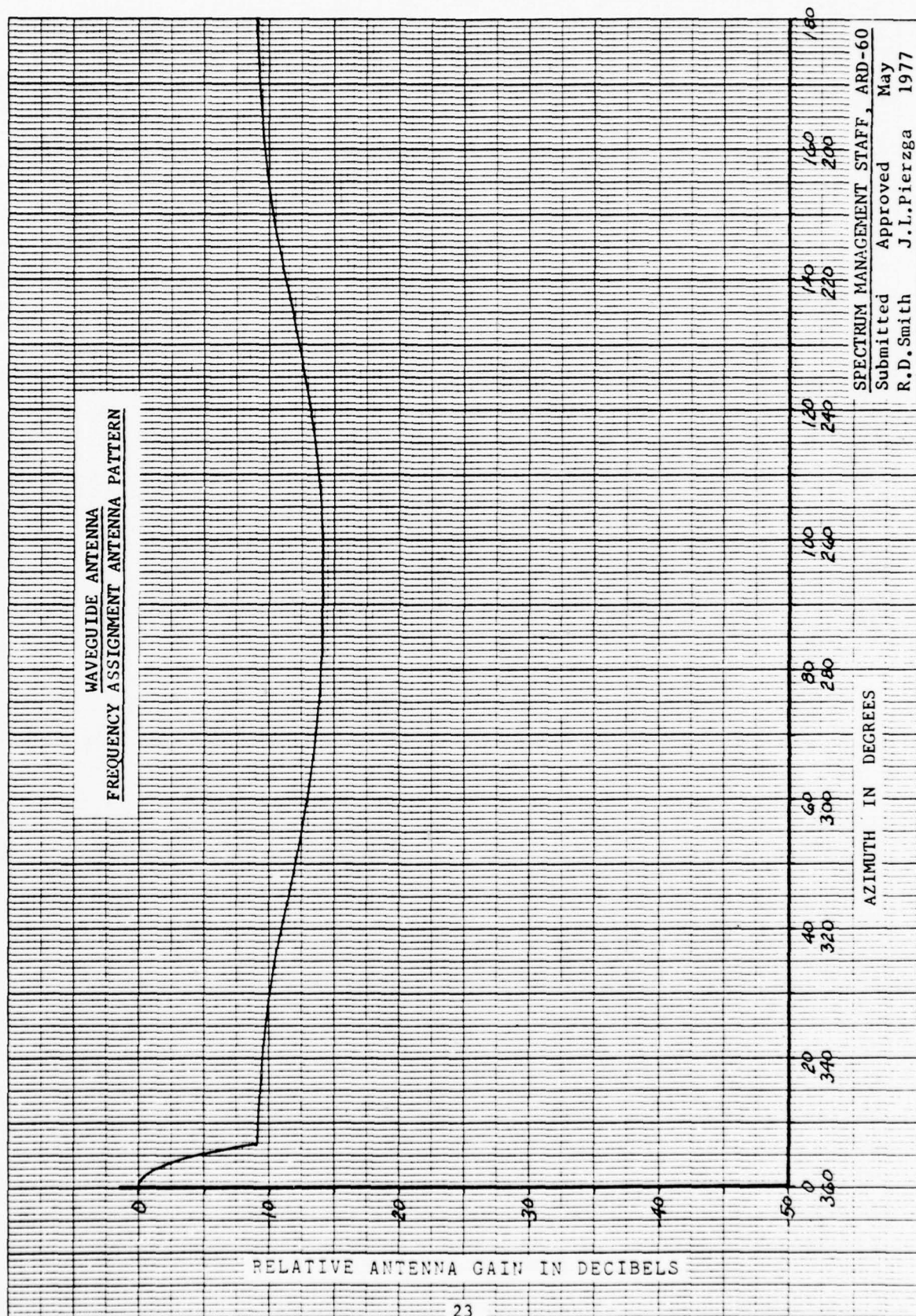


FIGURE 17

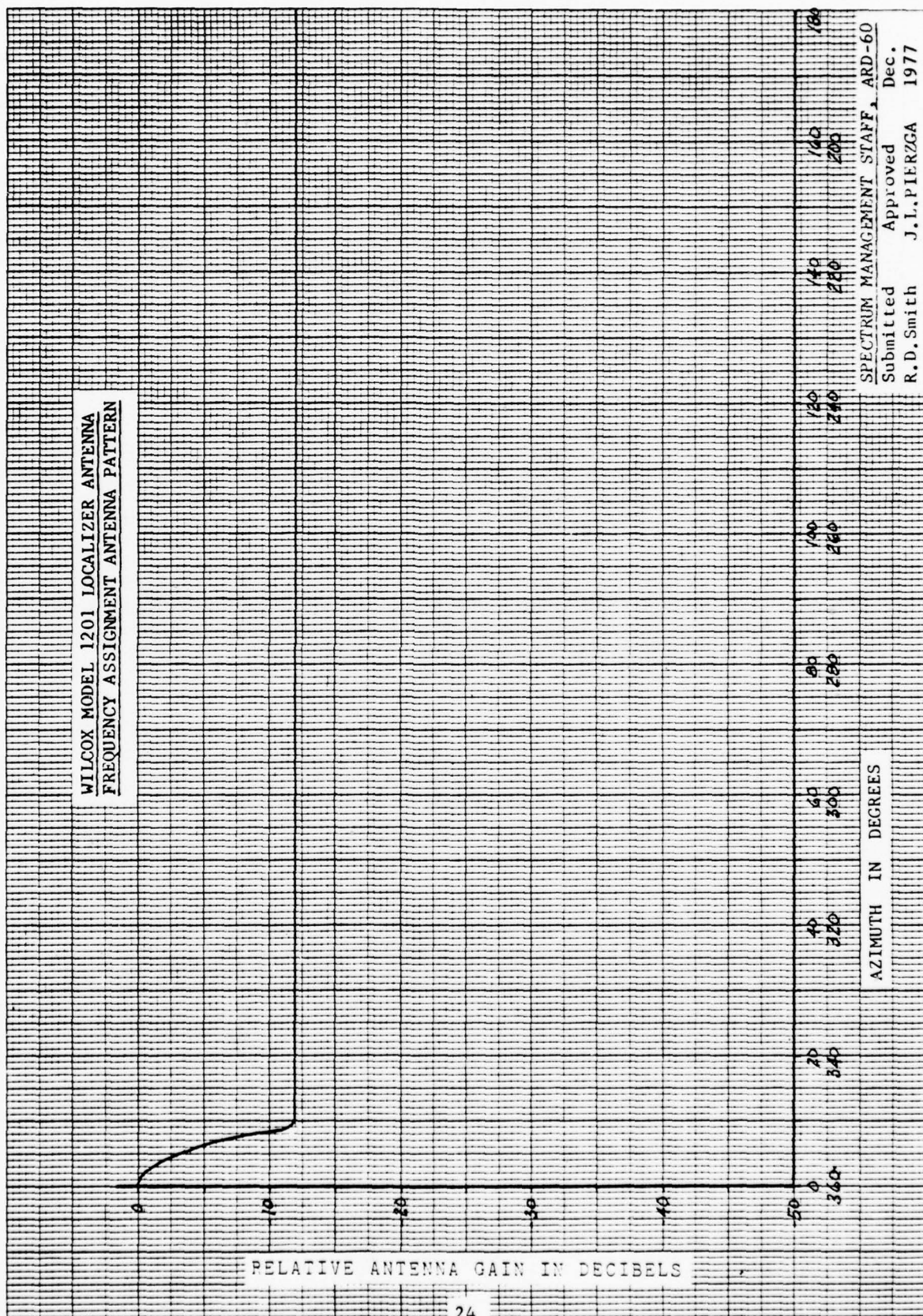


FIGURE 18

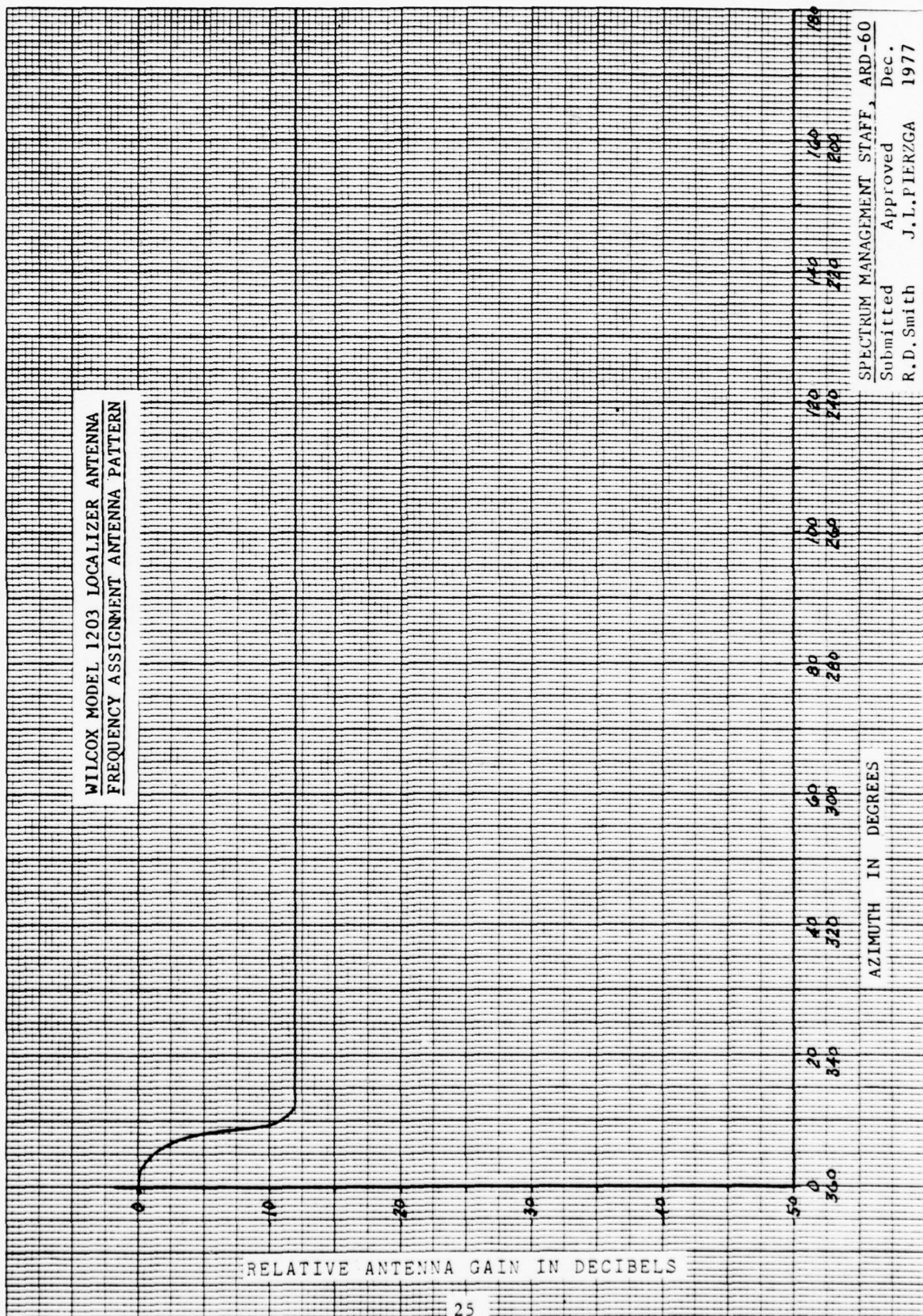


FIGURE 19

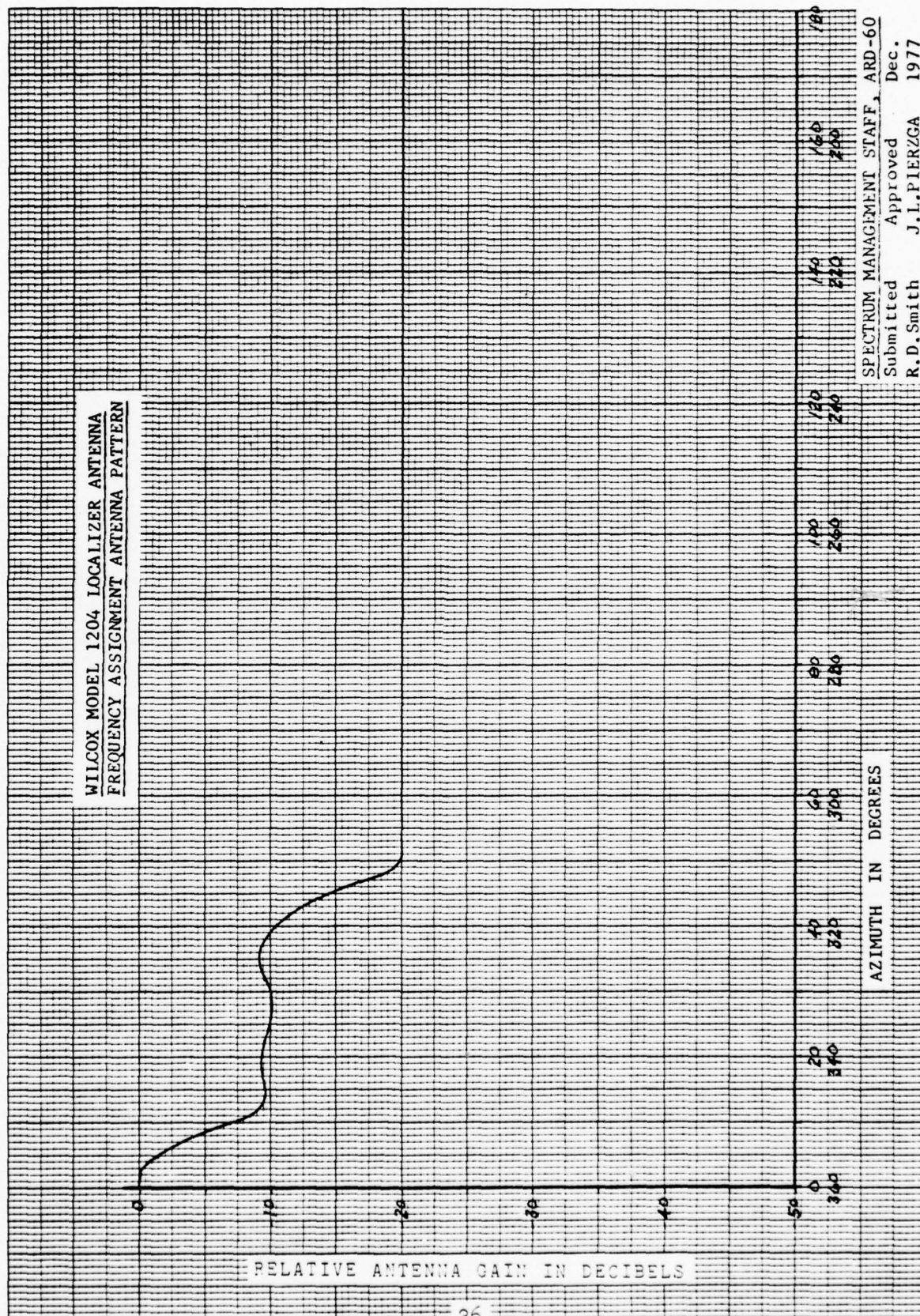


FIGURE 20

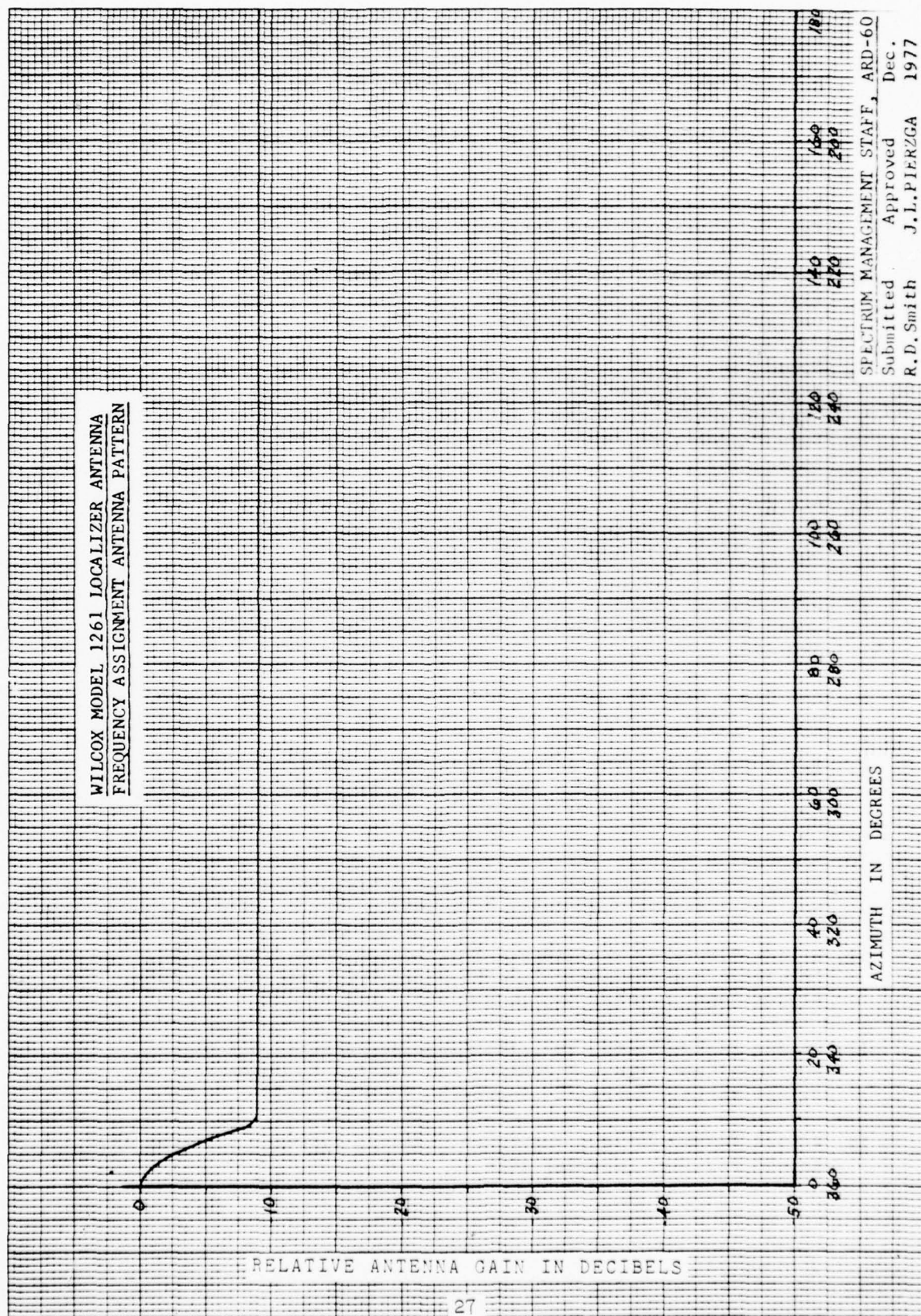


FIGURE 21

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ACRONYMS AND ABBREVIATIONS

AAF-420	Airways Facilities, Approach and Landing Aids Branch
AGC	Automatic Gain Control
AGL	Above Ground Level
A.I.L.	A Division of Cutler Hammer
A.M.C.	Alford Manufacturing Company
A.P.C.	Antenna Products Company
ARD-60	FAA Spectrum Management Staff
CCW	Counter clockwise
dB	Decibel
DWG	Drawing
FINFO	Flight Inspection National Field Office
FMO	Frequency Management Officer
ILS	Instrument Landing System
ITS	Institute of Telecommunication Sciences
kHz	Kilohertz
km	Kilometer
L.P.D.	Log Periodic Dipole
MHz	Megahertz
NAFEC	National Aviation Facilities Experimental Center
N-59	Nomenclature for a flight inspection aircraft
NM	Nautical Mile
nmi.	Nautical Mile
OKC	Oklahoma City
RCVR	Receiver

RW	Runway
SN	Serial Number
T.I.	Texas Instruments
VHF	Very High Frequency

APPENDIX A

This appendix contains the AGC calibration curves which were used to transform strip chart recordings into ILS antenna patterns. These patterns are shown in Appendix B where the relative power is expressed in decibels. In addition, they are shown in Appendix C where they are expressed as microvolts at the aircraft antenna output.

Also included in this appendix is the calibration curve of the spectrum analyzer which was on the FINFO aircraft. This instrument was used to allow the simultaneous measurement of the course and clearance patterns of two frequency arrays at the same time that the overall AGC pattern was being measured. Comparisons are made between the data obtained by these two methods. These comparisons are shown in Appendixes A and B. The data has been manipulated to show slightly different things in each appendix. Differences are explained in detail at the beginning of each appendix.

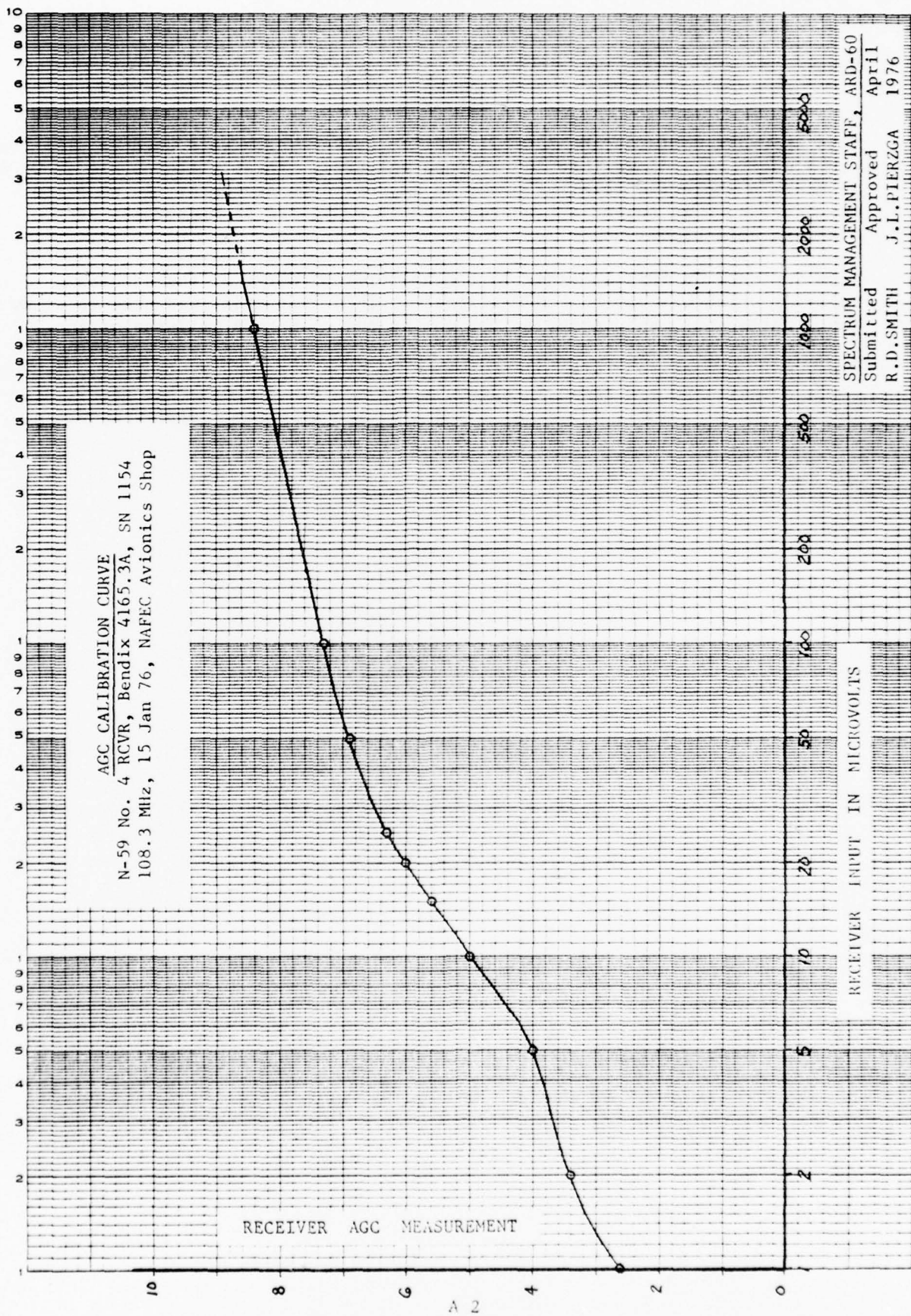


FIGURE A 1

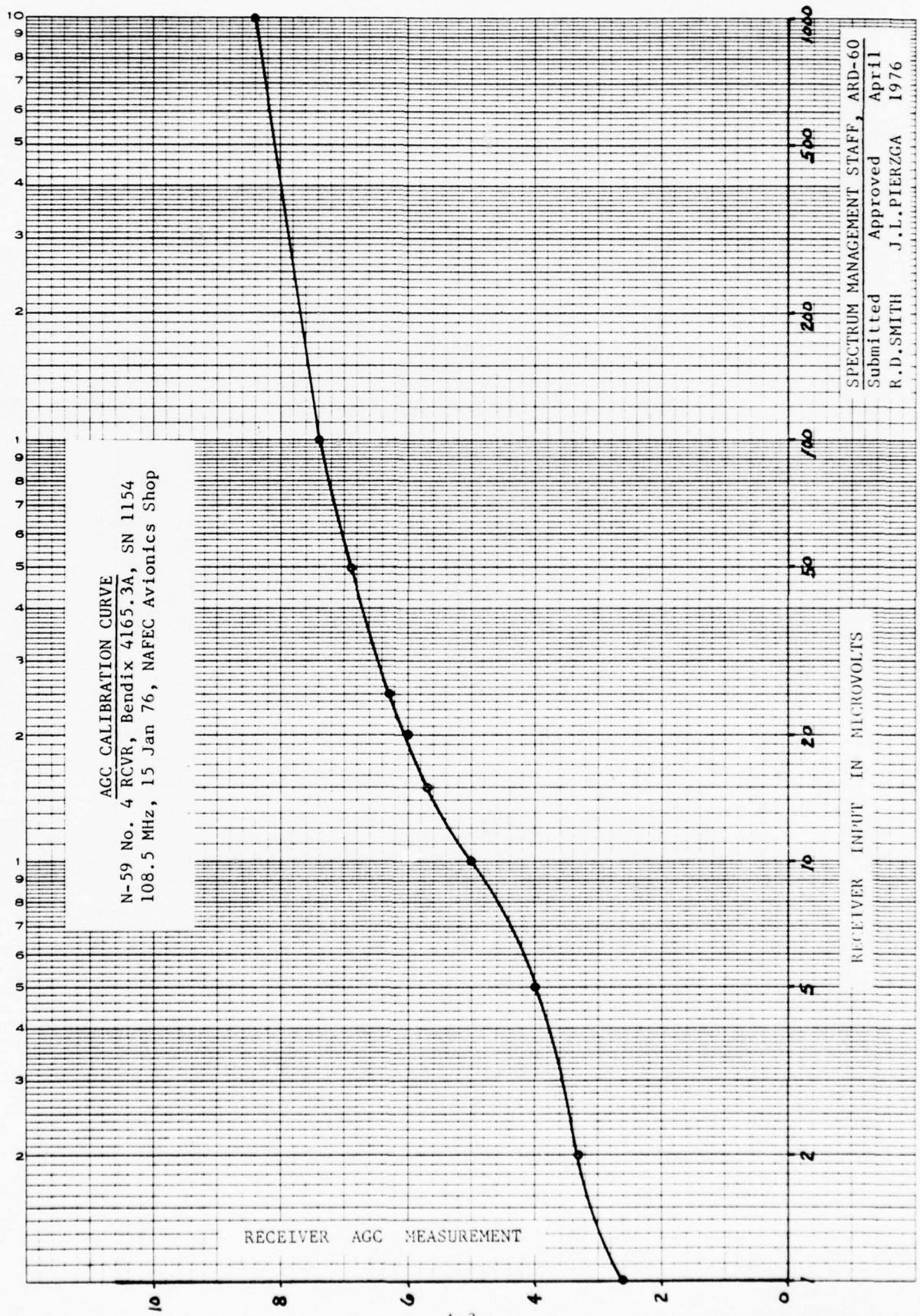


FIGURE A 2

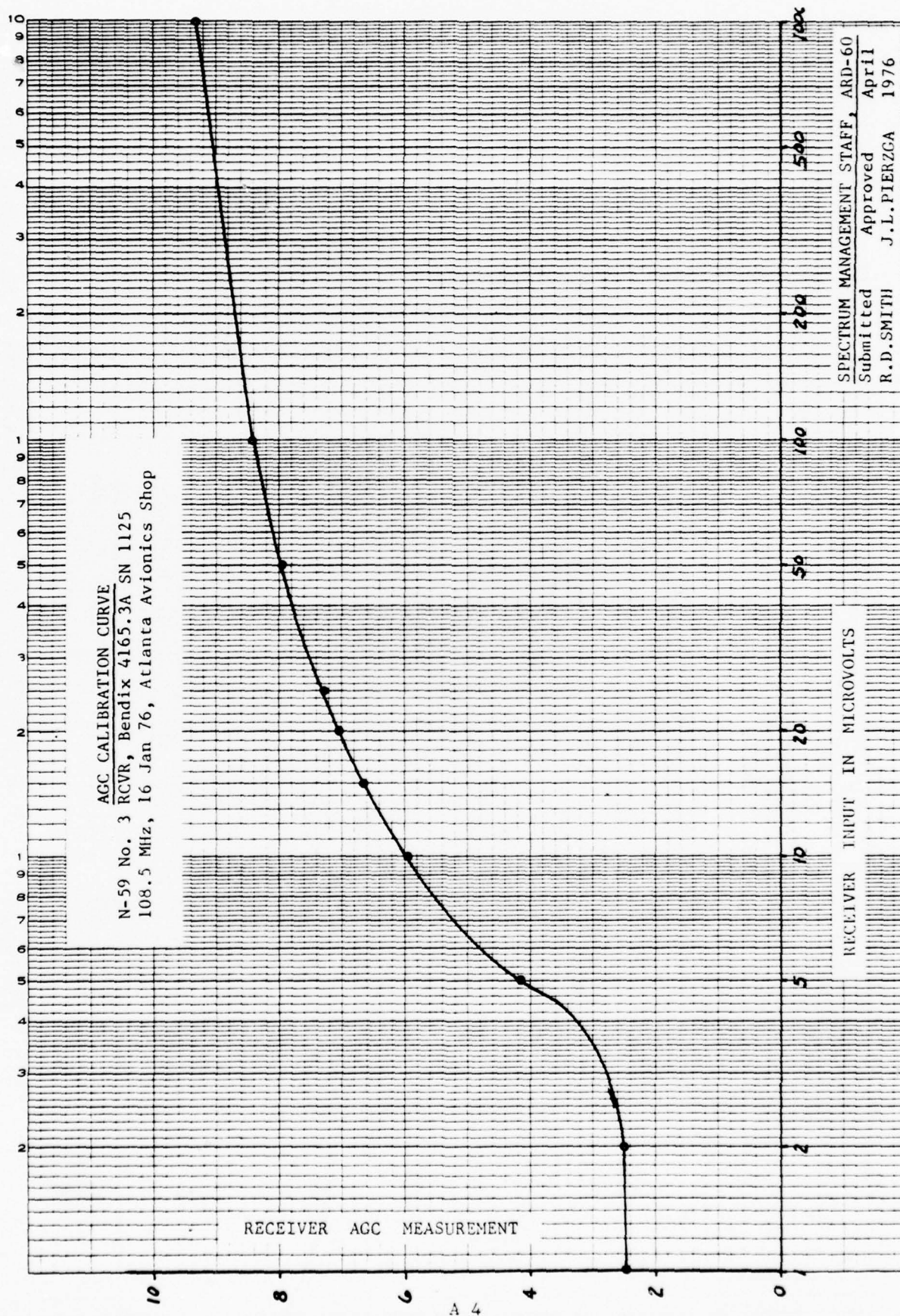


FIGURE A 3

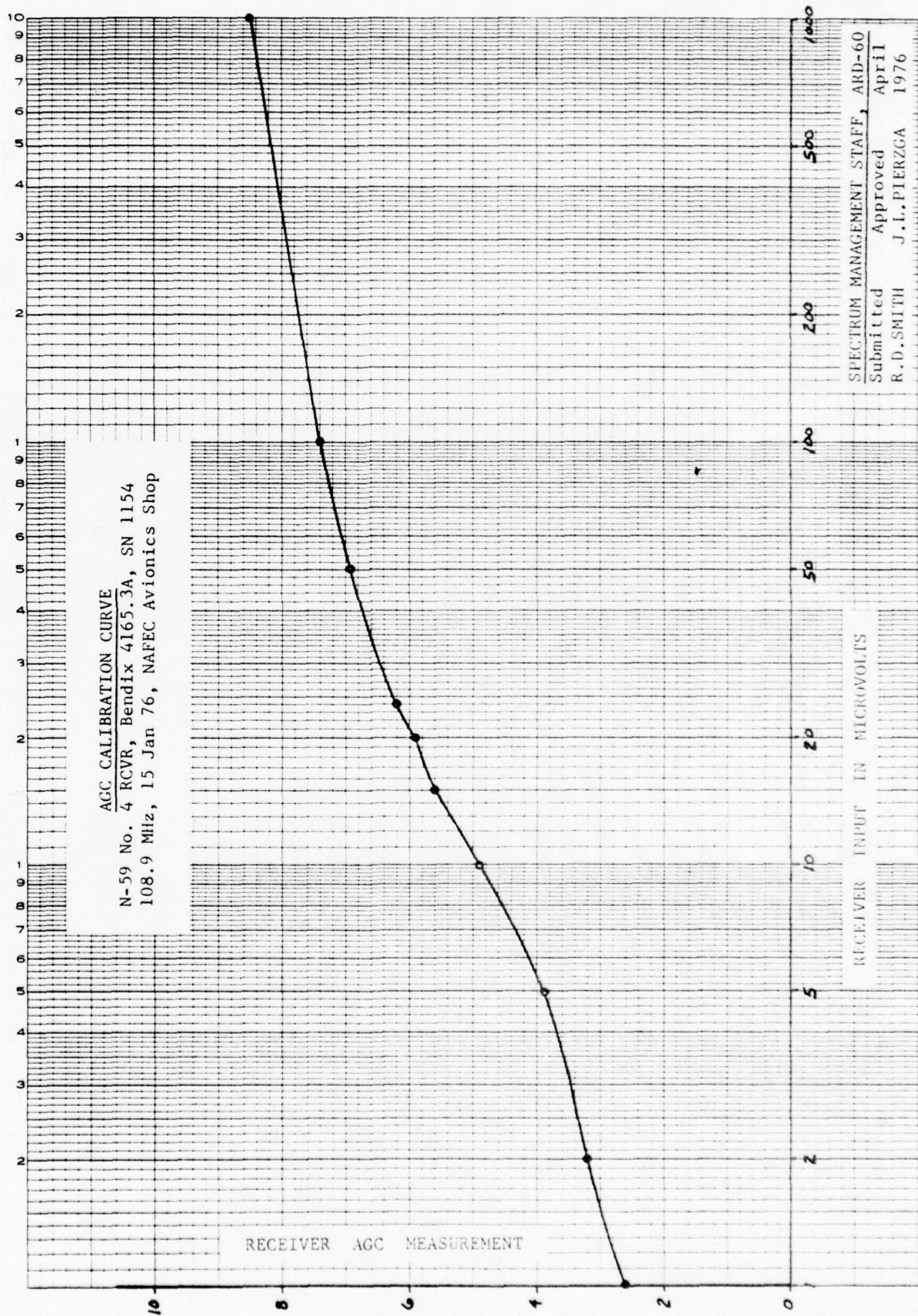


FIGURE A 4

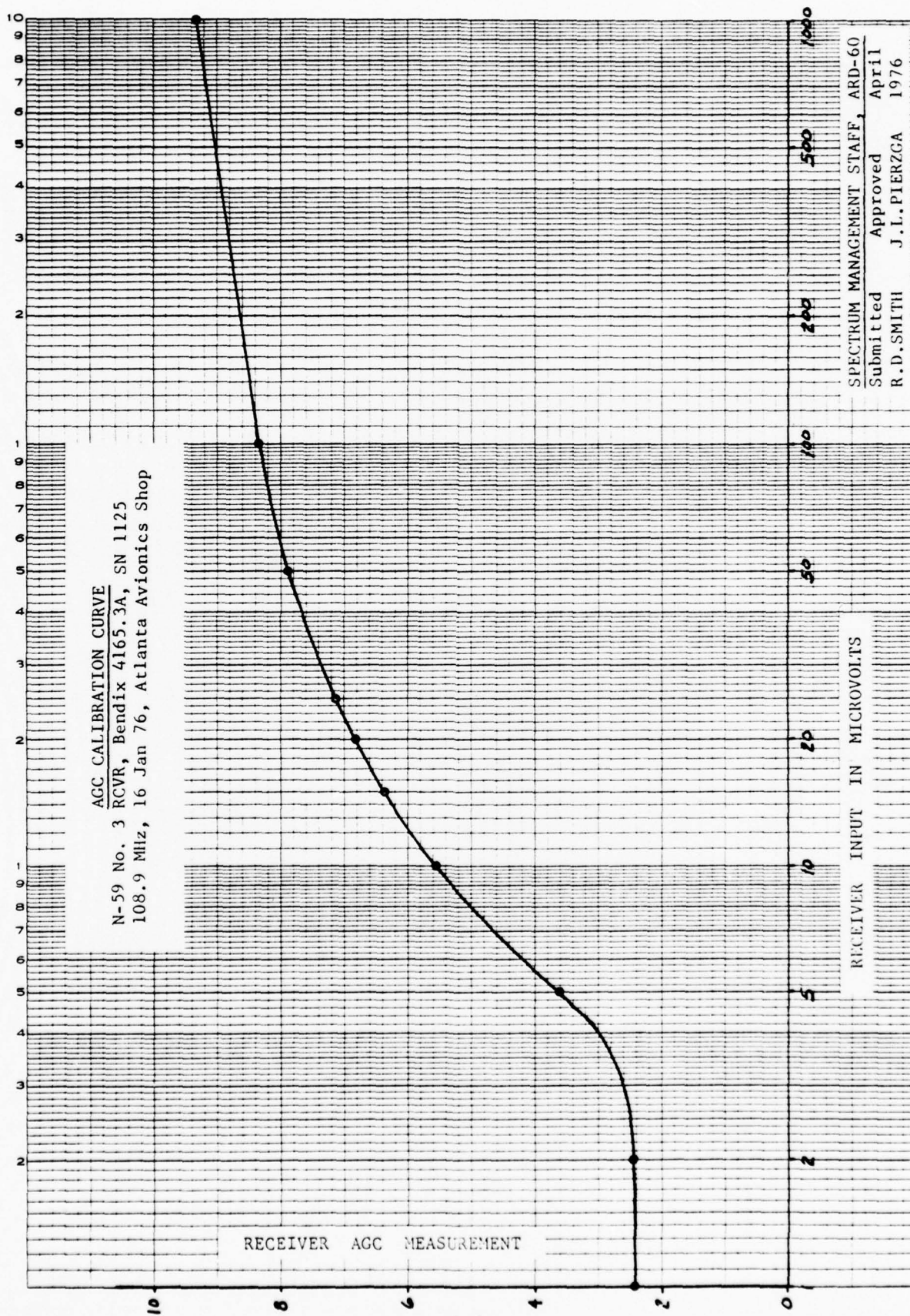


FIGURE A 5

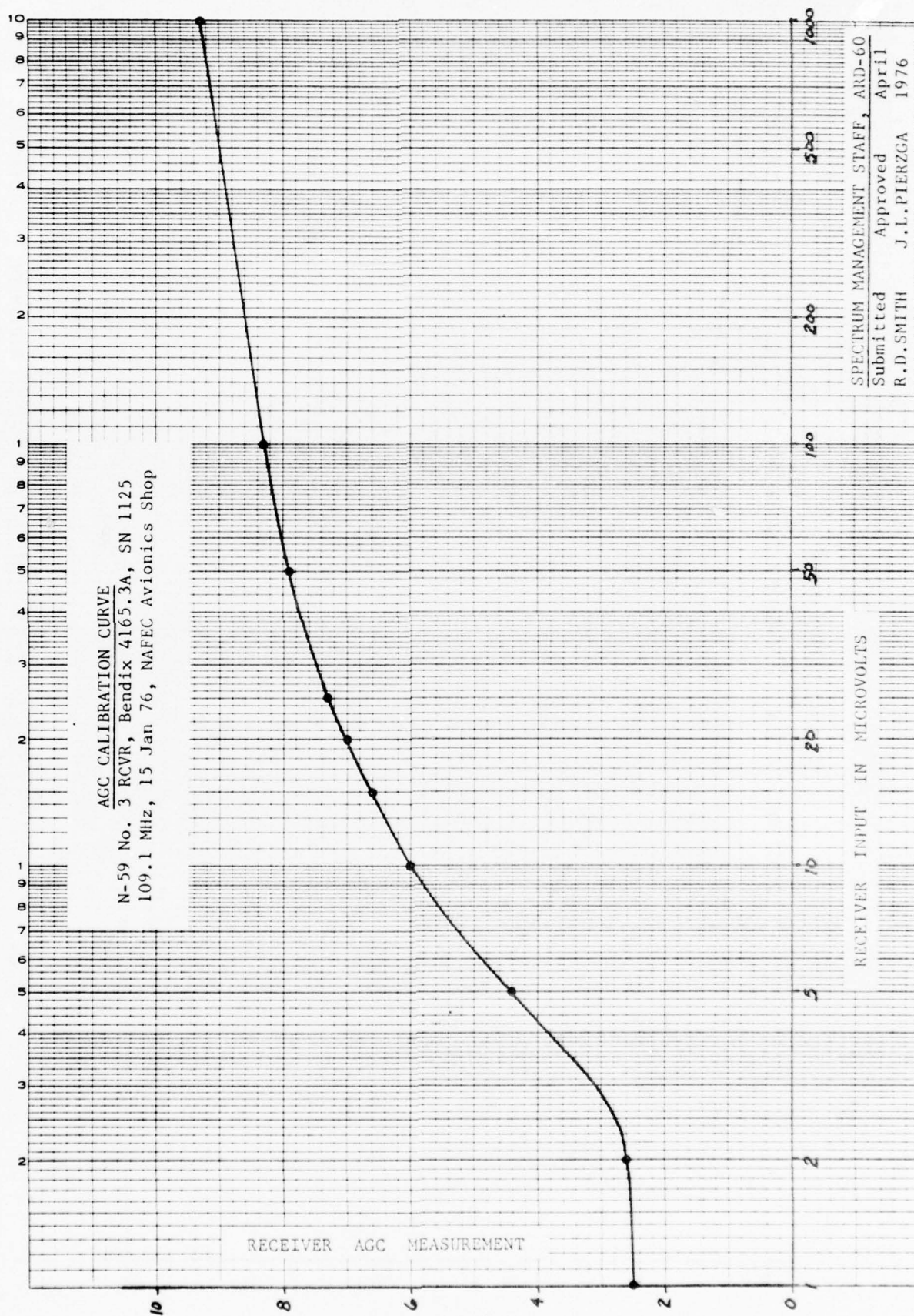


FIGURE A 6

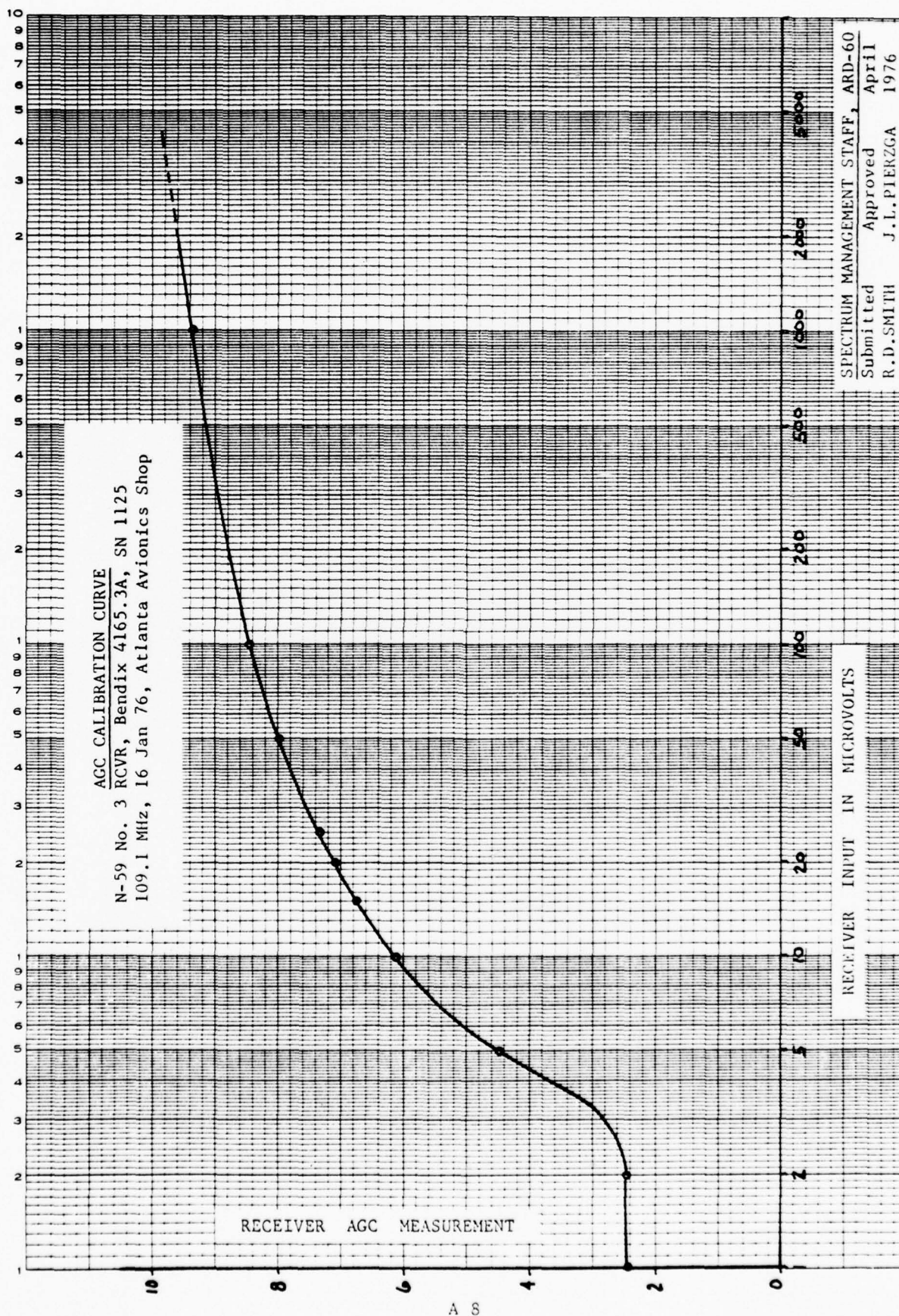


FIGURE A 7

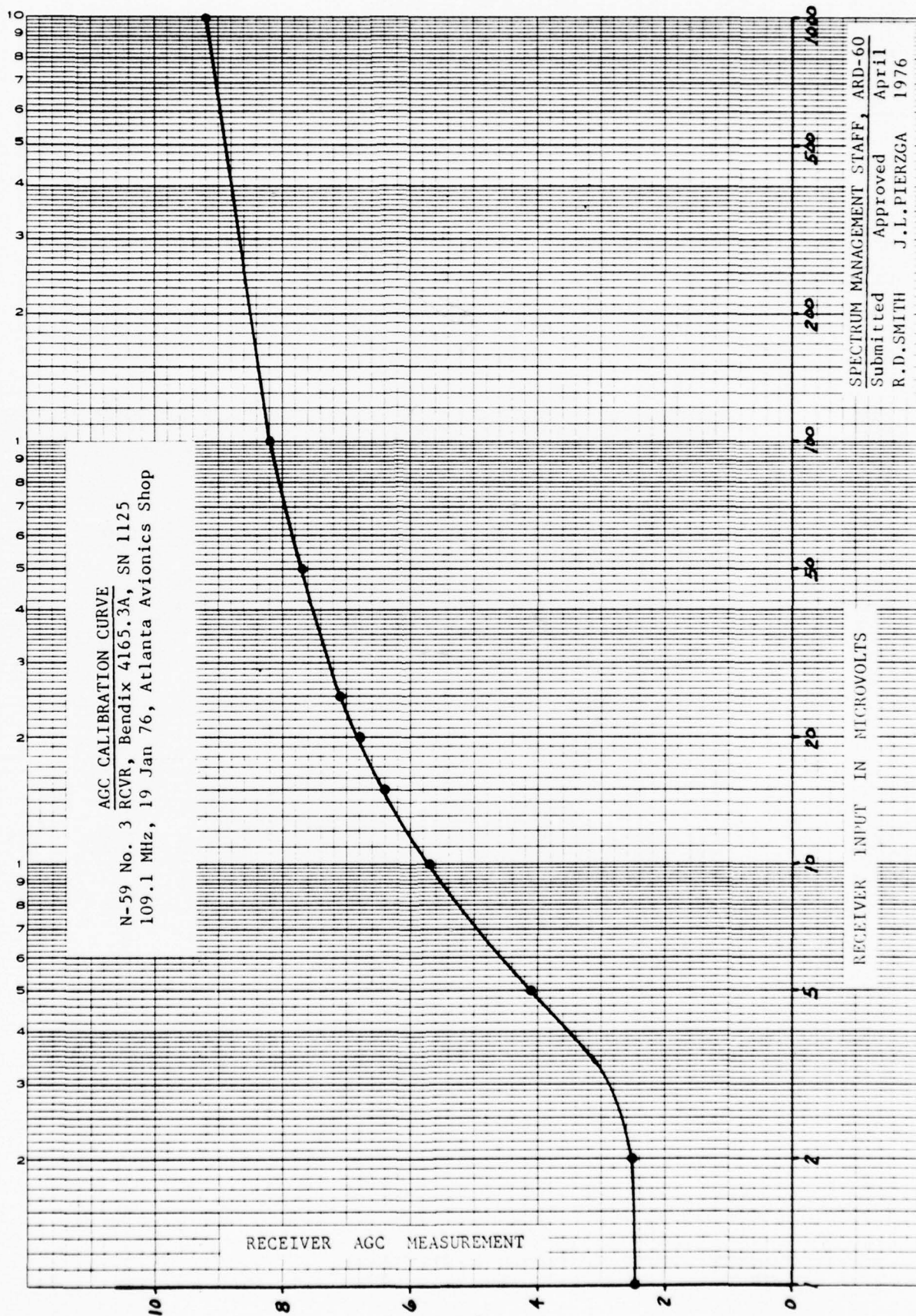


FIGURE A 8

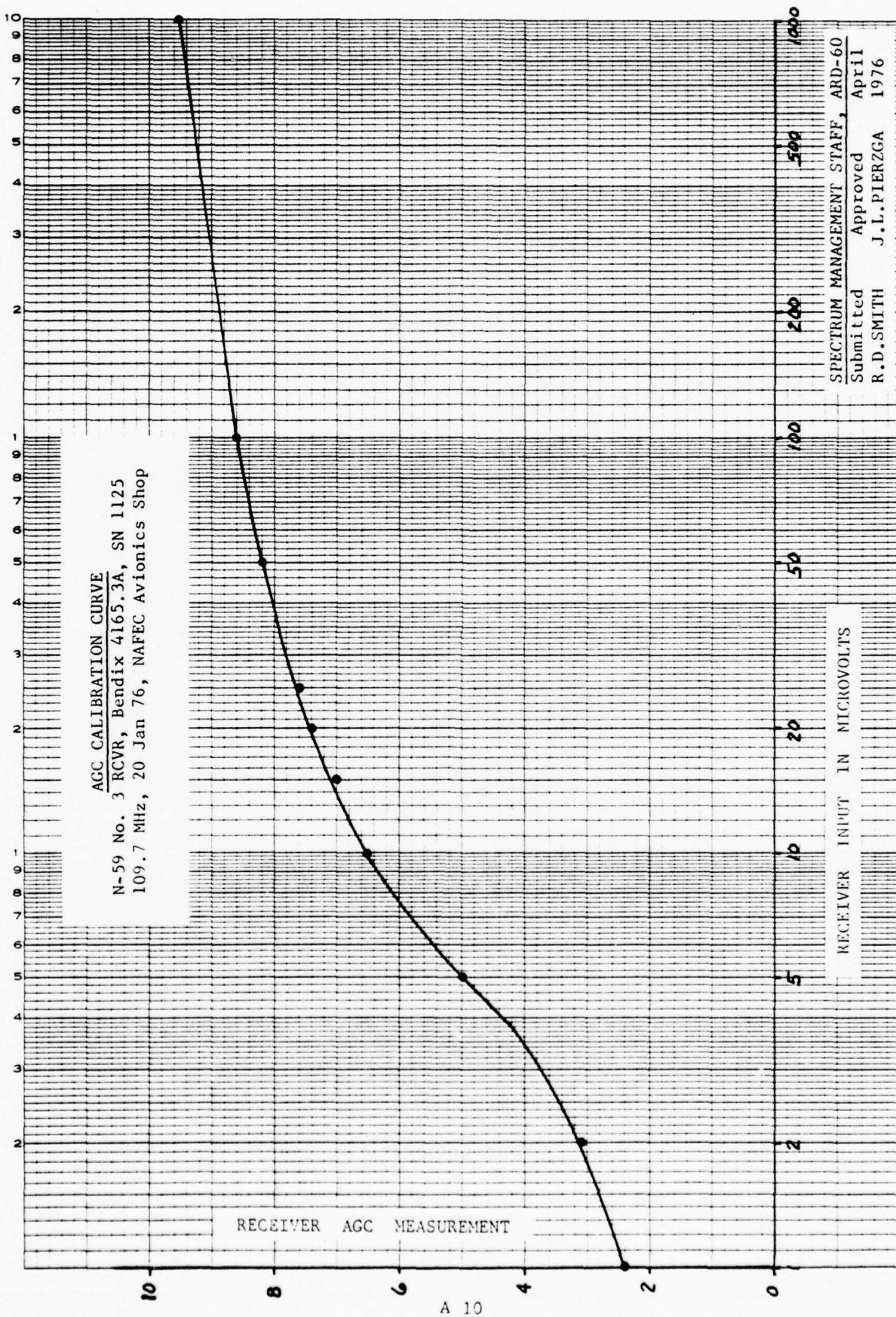


FIGURE A 9

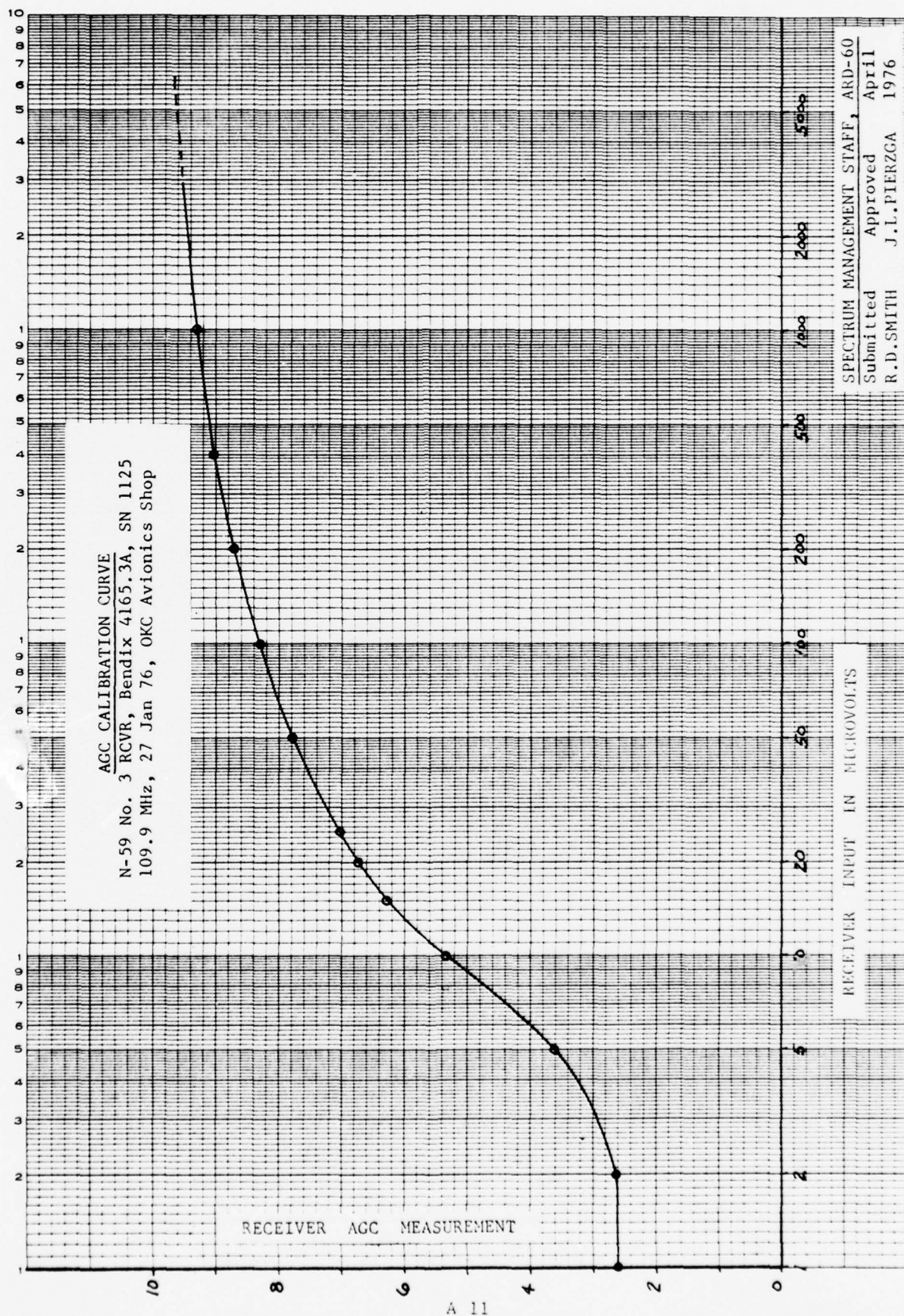


FIGURE A 10

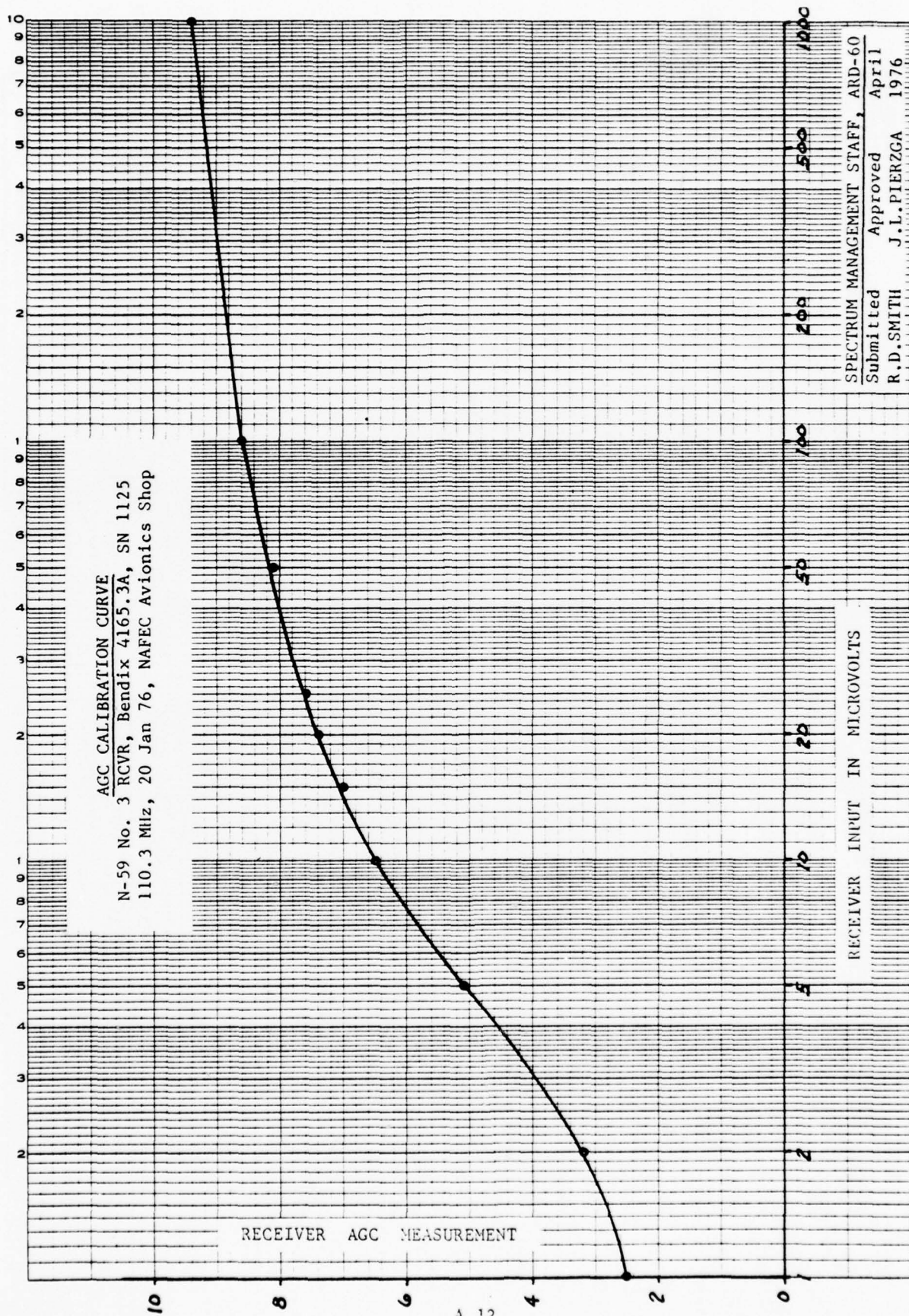


FIGURE A 11

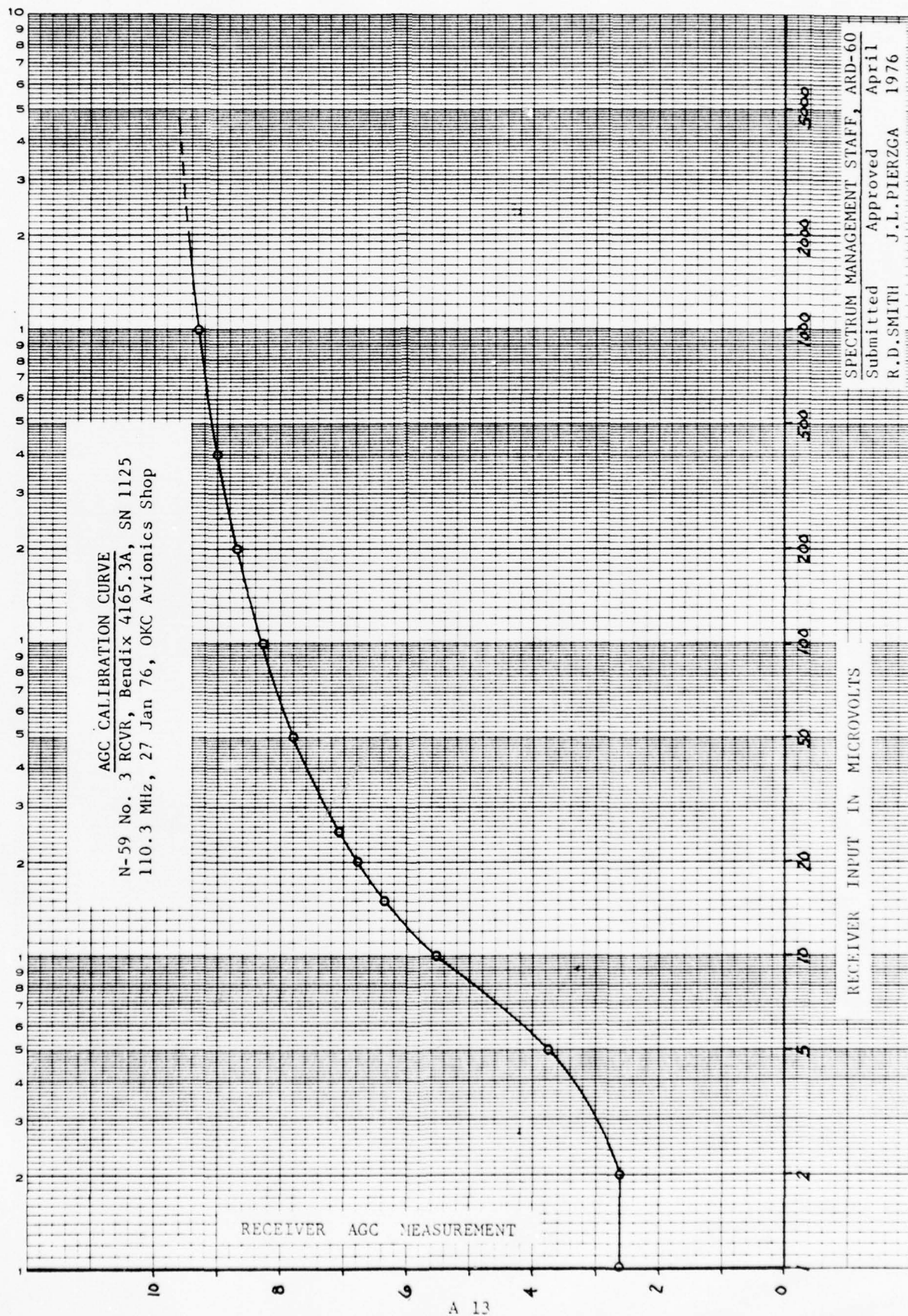


FIGURE A 12

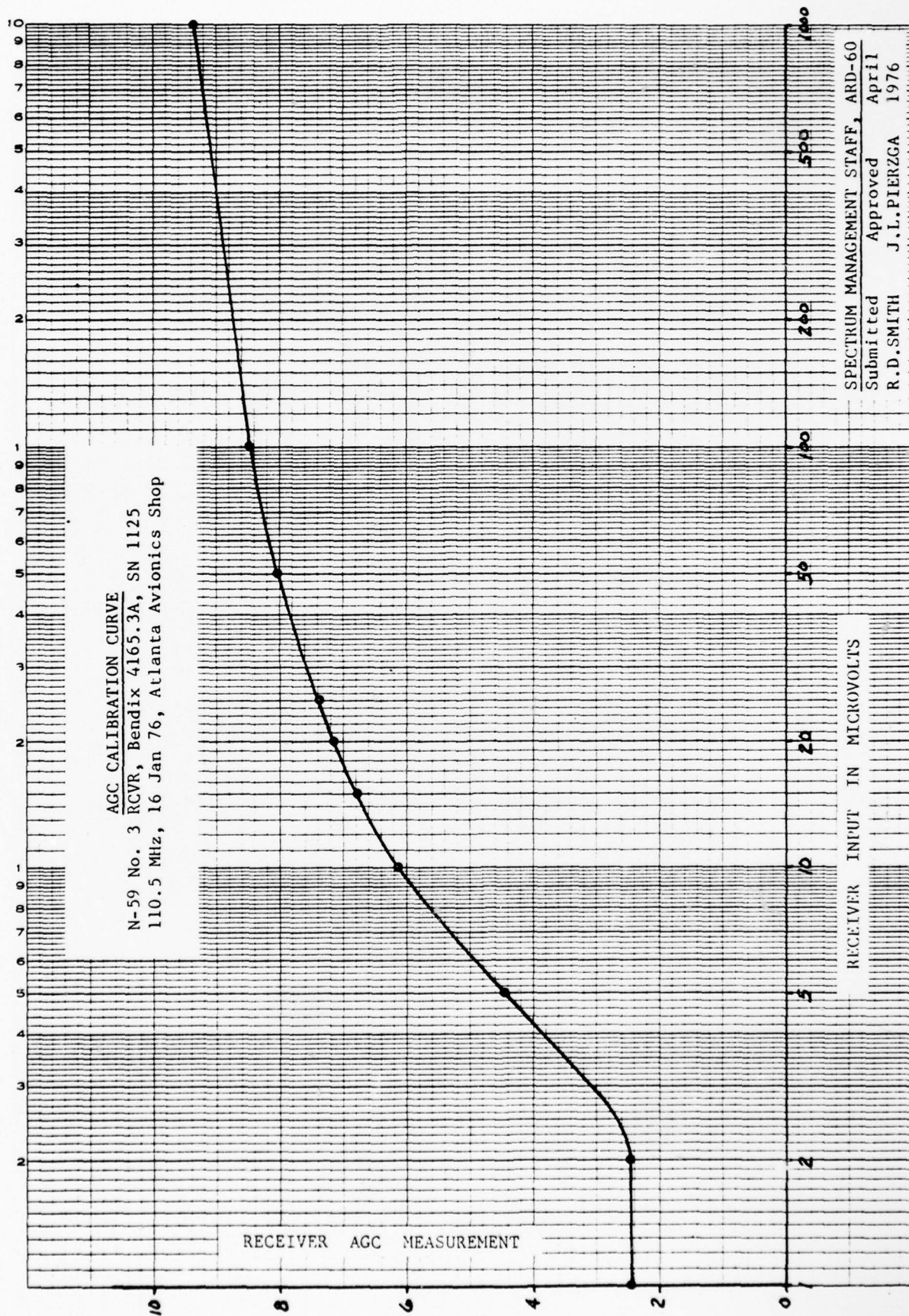


FIGURE A 13

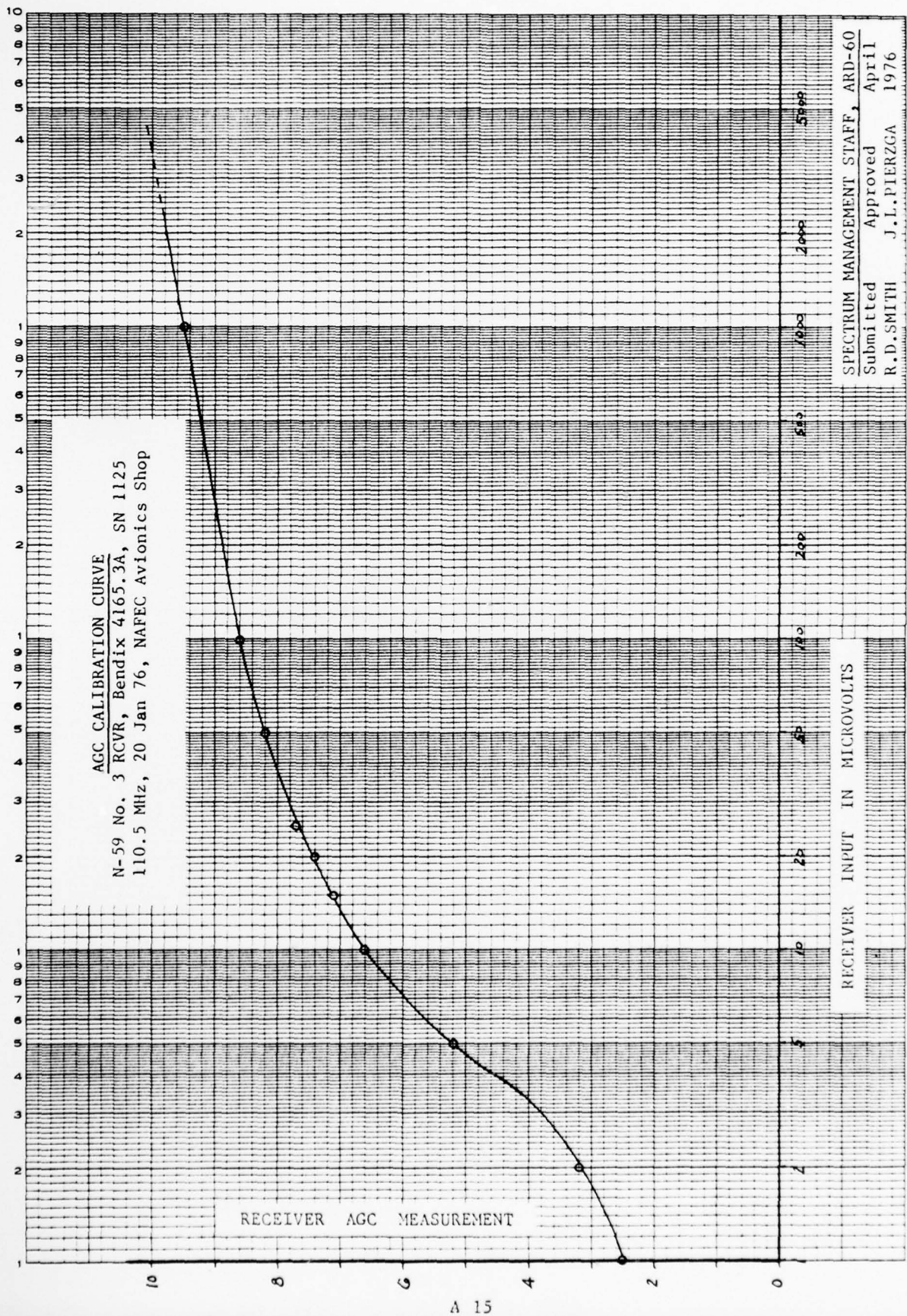


FIGURE A 14

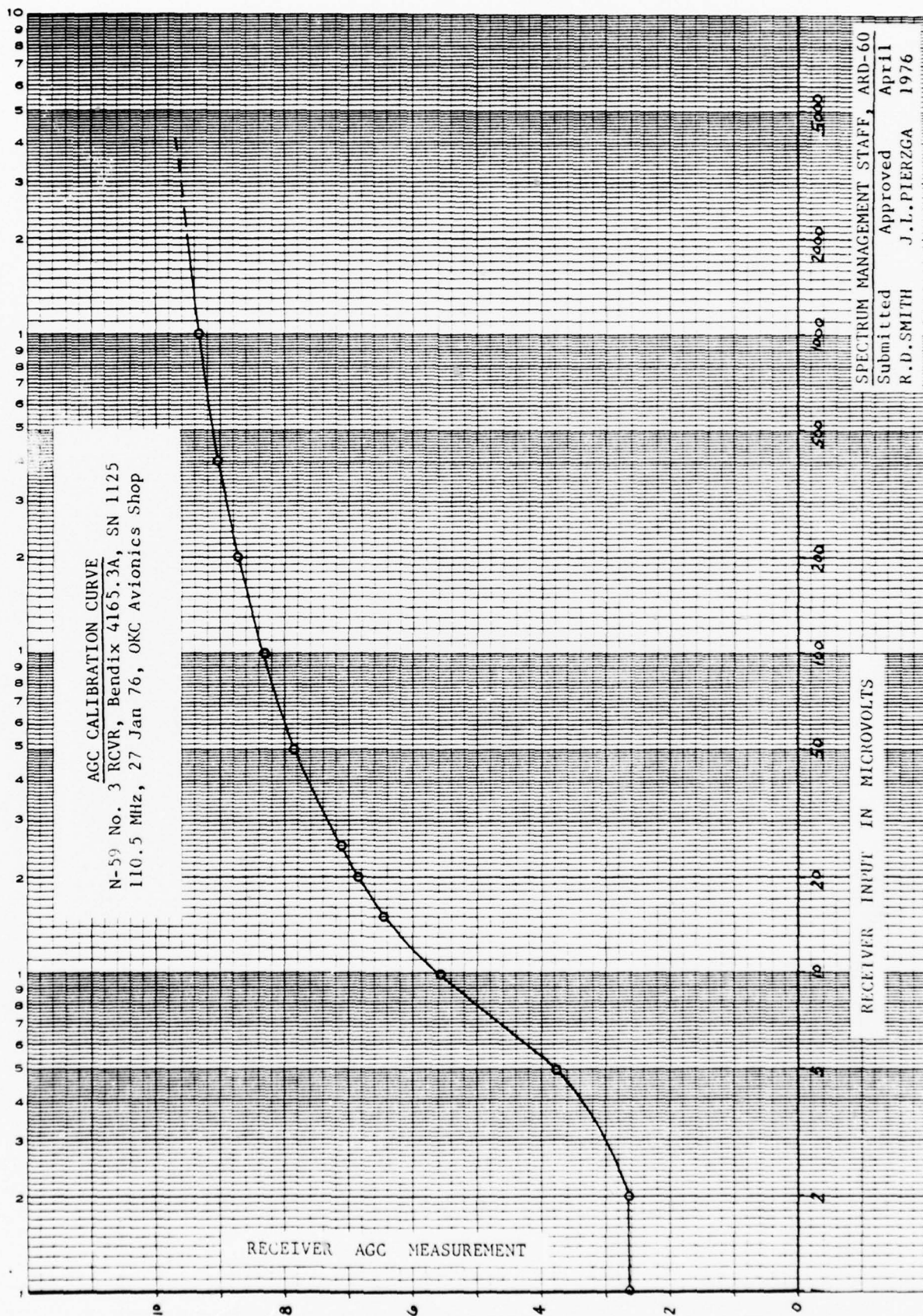


FIGURE A 15

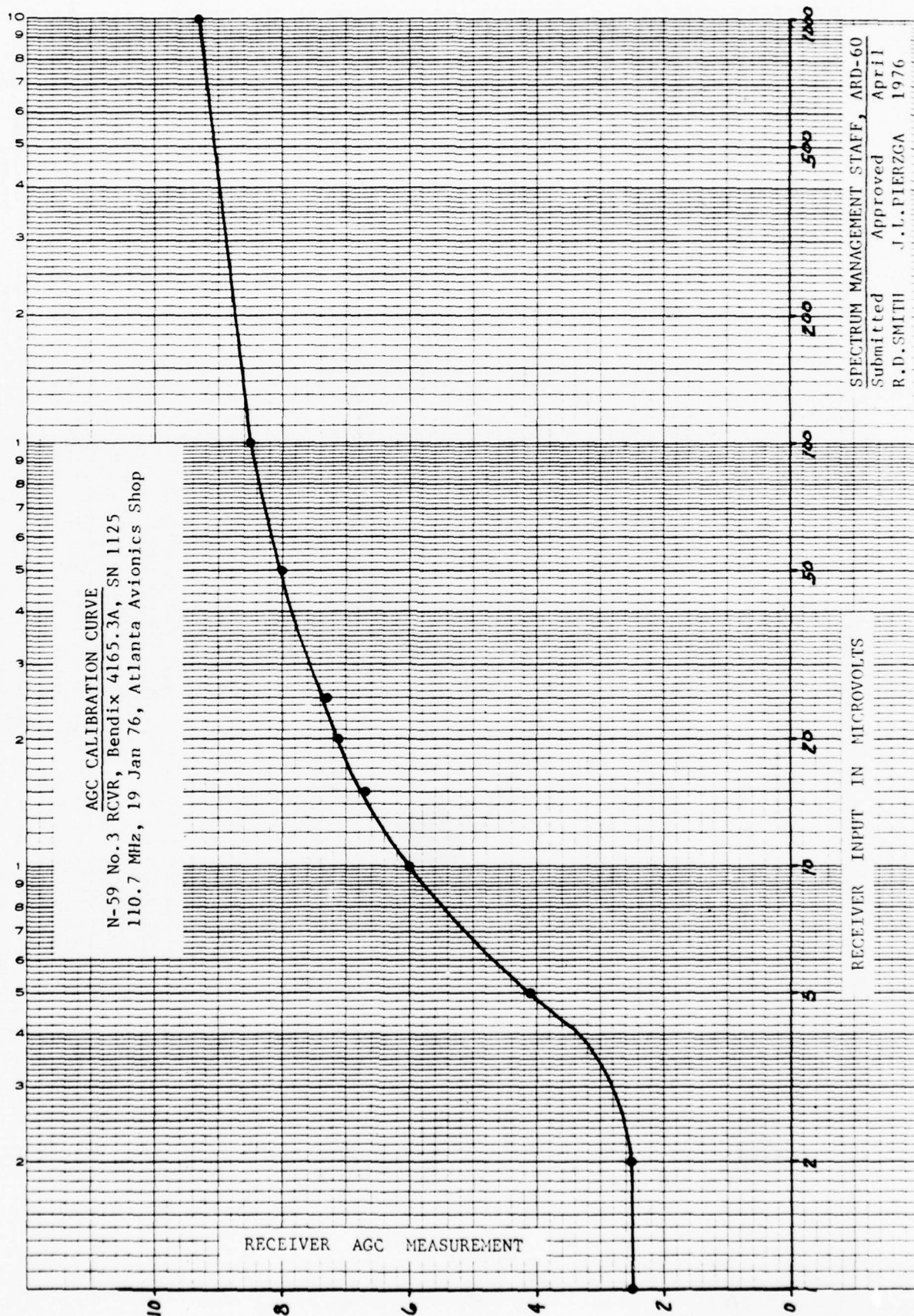


FIGURE A16

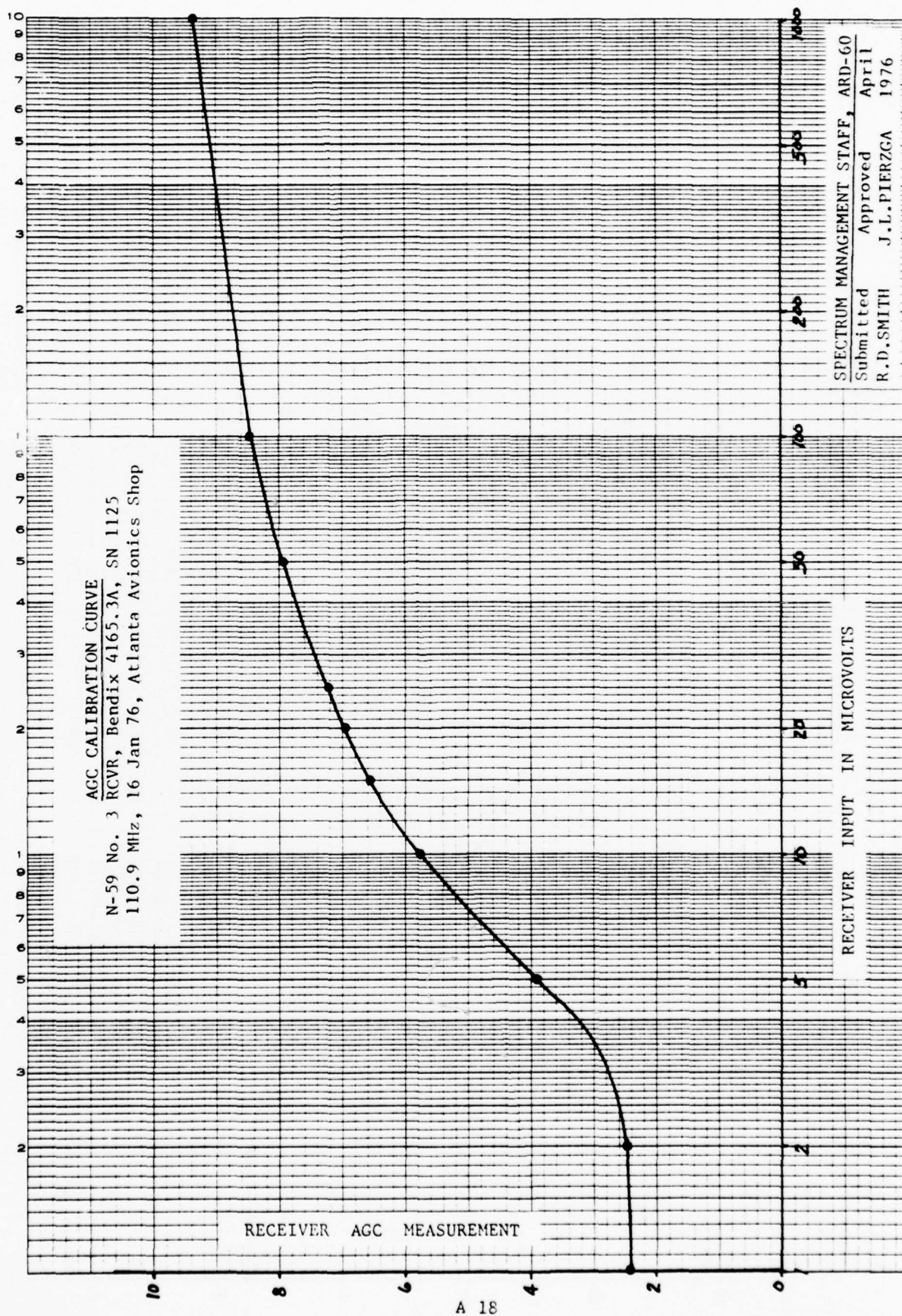


FIGURE A 17

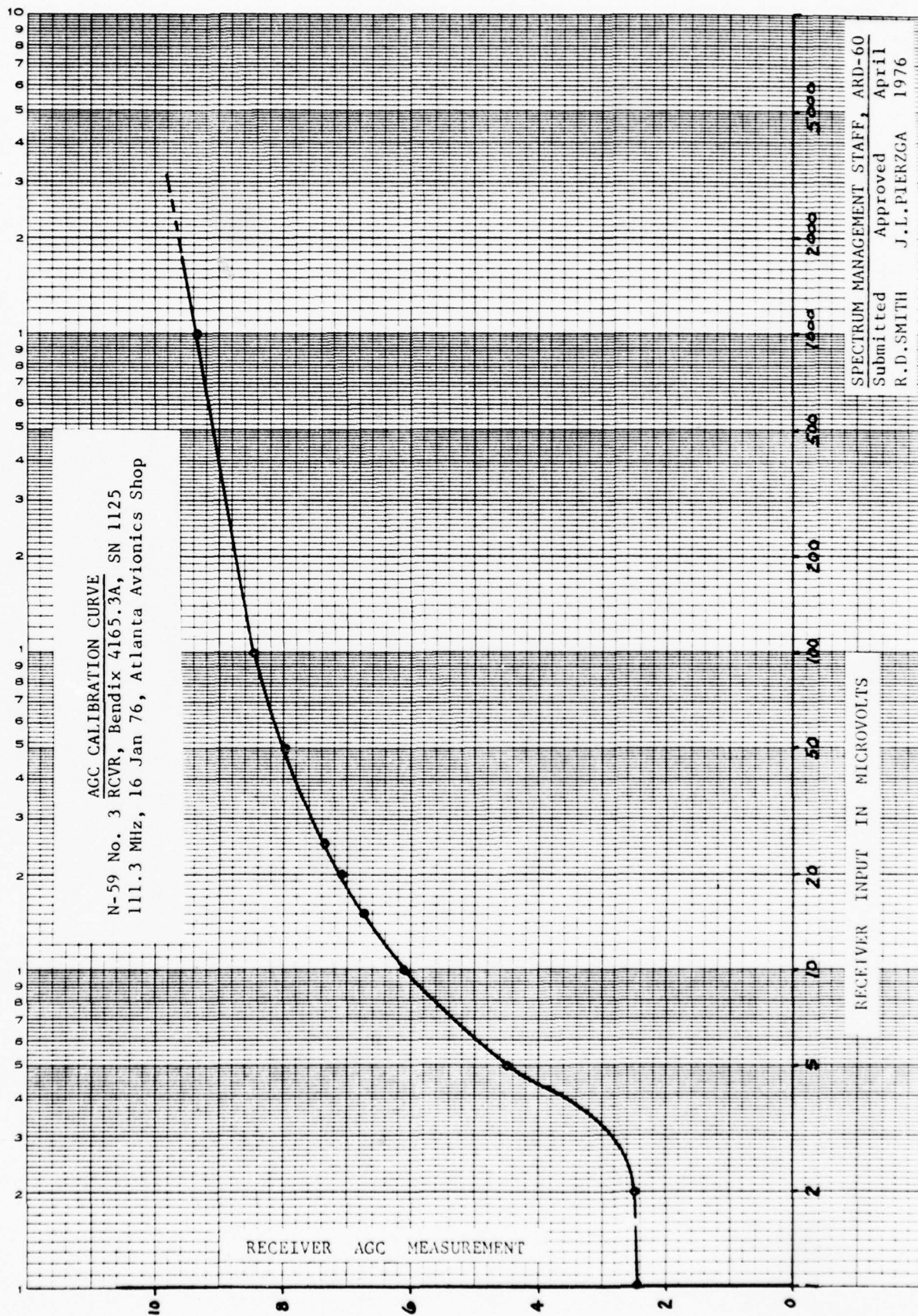


FIGURE A 18

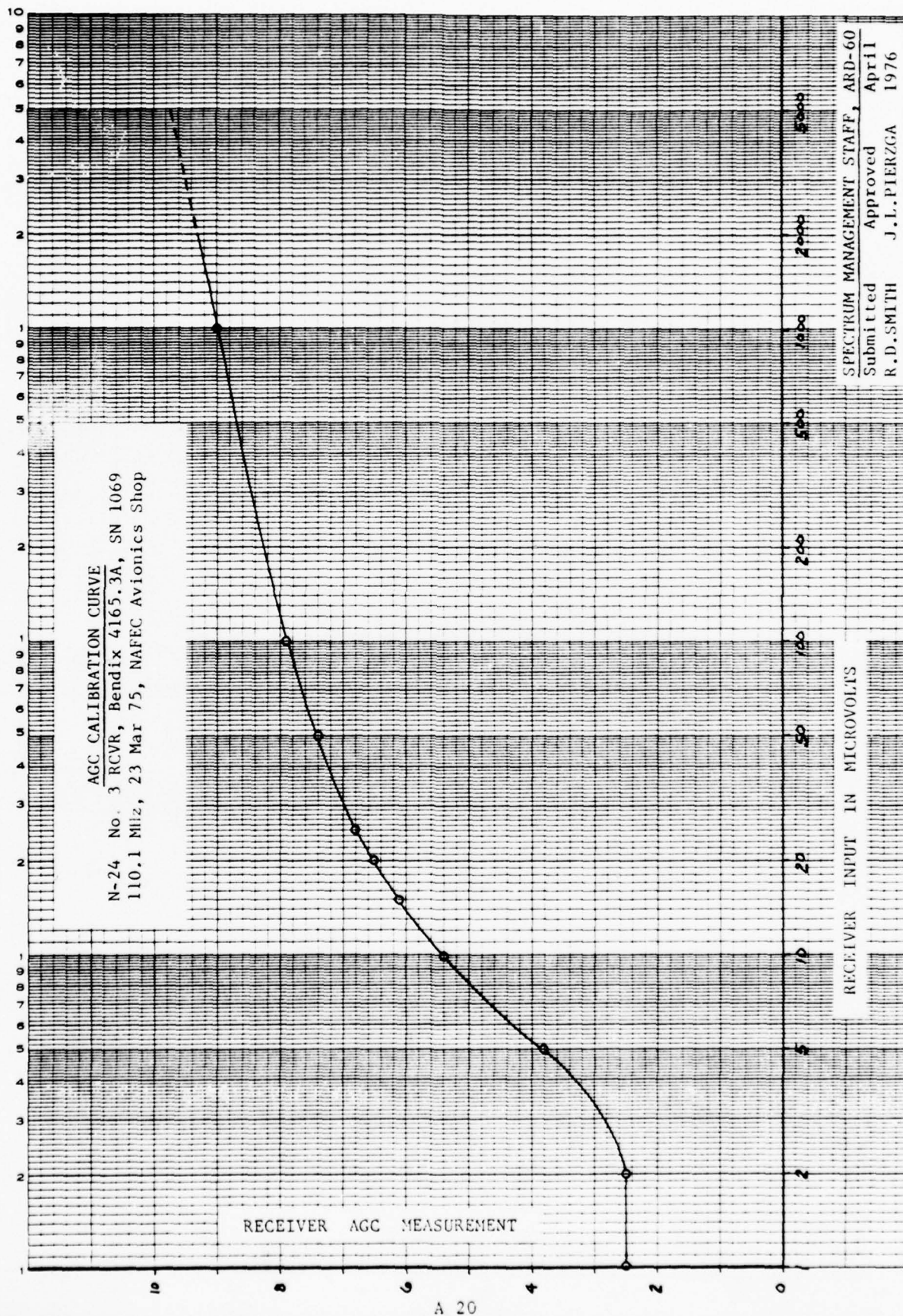


FIGURE A 19

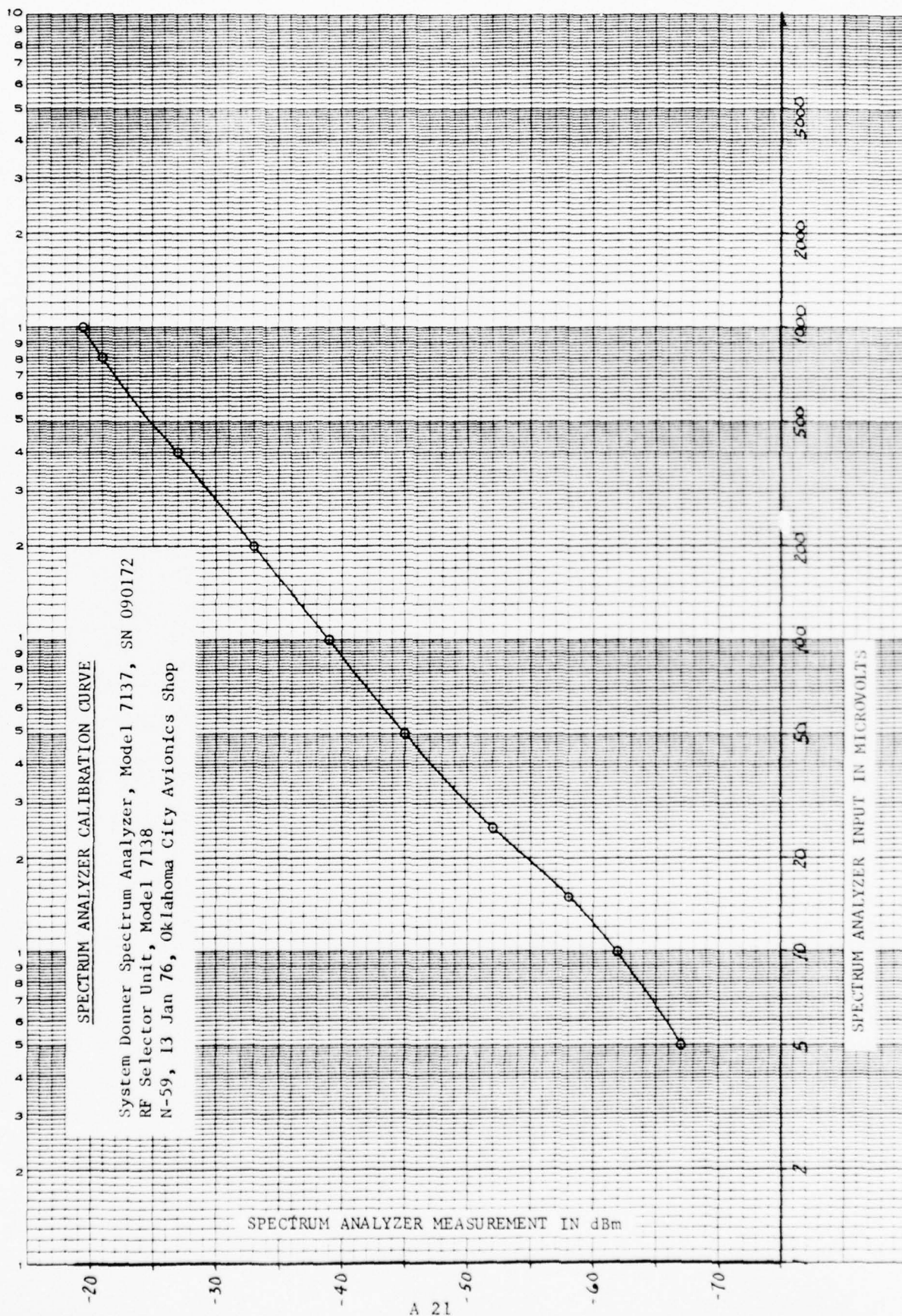


FIGURE A 20

APPENDIX B

This appendix contains a comparison of ILS antenna patterns which were obtained through two methods. The first method is the standard procedure of reducing AGC data to microvolts and then expressing the relative power in decibels with respect to the mainbeam. The second method involves the use of a spectrum analyzer. This instrument allows the discrimination between the respective signals of the course and clearance arrays of two frequency capture effect ILS localizers. In this manner, simultaneous measurement of the course and clearance patterns was possible at the same time that the ILS receiver was measuring the resulting pattern via the standard procedure.

The spectrum analyzer was also used to measure the patterns of single frequency arrays. This was done in order to build up experience in the mechanics of this type of measurement and to provide a larger data base with which to compare the two techniques. Due to the methods used in data reduction, the patterns given in this appendix can only be used for a comparison of the relative patterns resulting from each technique. For each orbit, the peak microvolt reading obtained from the AGC data was assigned the value of zero dB and the remaining AGC data was plotted with respect to this point. For each orbit, the peak value obtained from the spectrum analyzer data was assigned the value of zero dB and the remaining spectrum analyzer data was plotted with respect to this point. The two sets of data are shown on the same graph. Some comparisons can be made, but the reader must keep in mind how the data has been manipulated.

This same data is also shown in Appendix C where it is expressed in terms of microvolts at the antenna output. In this case, each method has been separately calibrated and direct comparisons can be made between the discrete values obtained.

Both Appendixes B and C show antenna patterns graphed in the same general manner. The right half of the pattern (from 0 to 180 degrees) is plotted on the same scale as the left half of the pattern (from 360 to 180 degrees). AGC data is shown as a continuous line while spectrum analyzer data is shown as discrete data points. Two symbols are used for spectrum analyzer data in order to distinguish between the course and clearance signals transmitted by two frequency arrays. The signal transmitted by the course array is shown as a triangle (Δ) and the signal transmitted by the clearance array is shown as a circle (\circ). When a spectrum analyzer data point between 0 and 180 degrees falls exactly on top of a data point between 180 and 360 degrees, this is indicated as follows:

1. A filled triangle (\blacktriangle) for two course data points.
2. A filled circle (\bullet) for two clearance data points.
3. A circle and a triangle ($\Delta \circ$) for one course data point and one clearance data point.

For single frequency arrays, spectrum analyzer data points are shown simply as circles. When a data point between 0 and 180 falls on top of a data point between 180 and 360 degrees, this is indicated by a filled circle (\bullet).

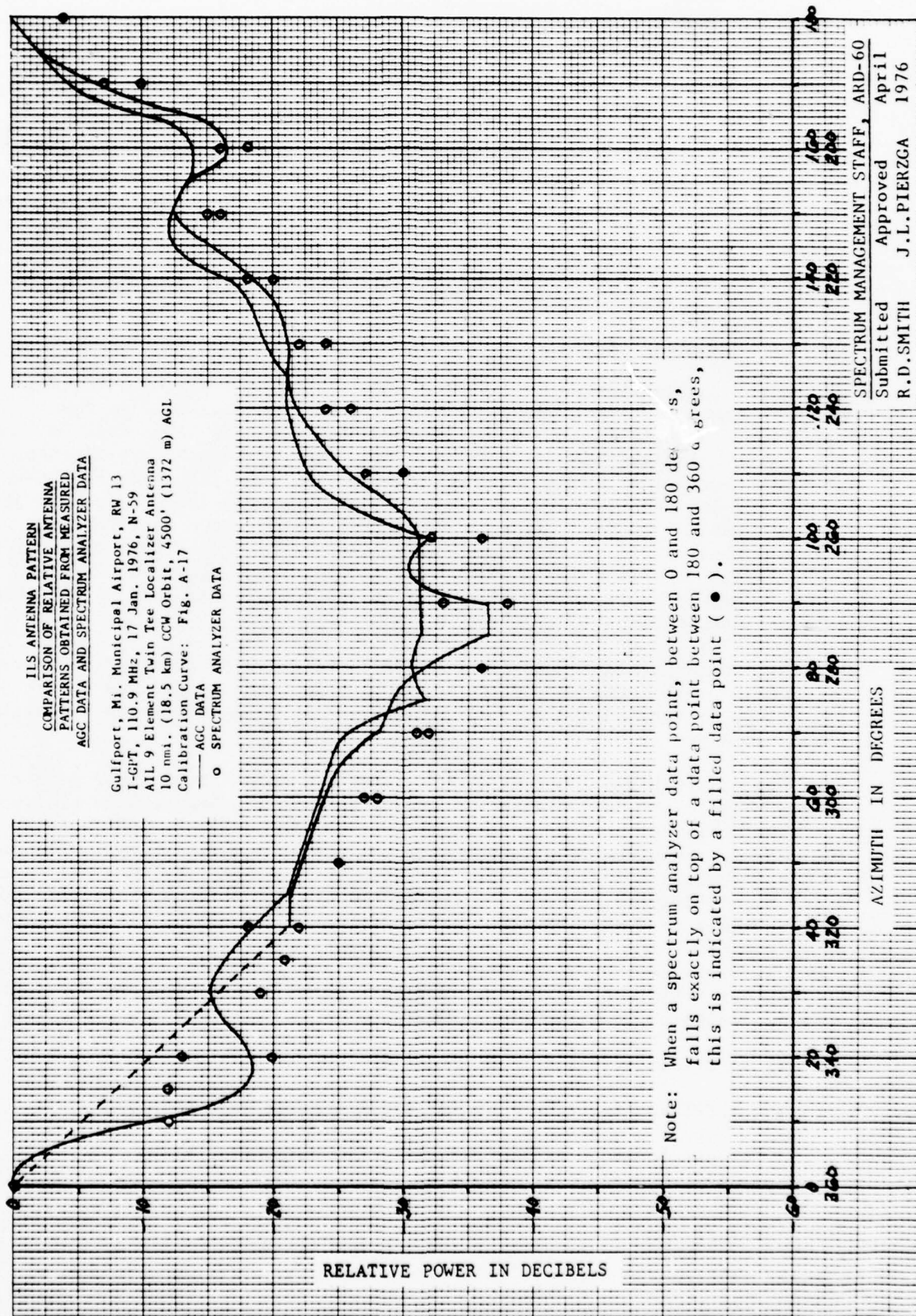


FIGURE B 1

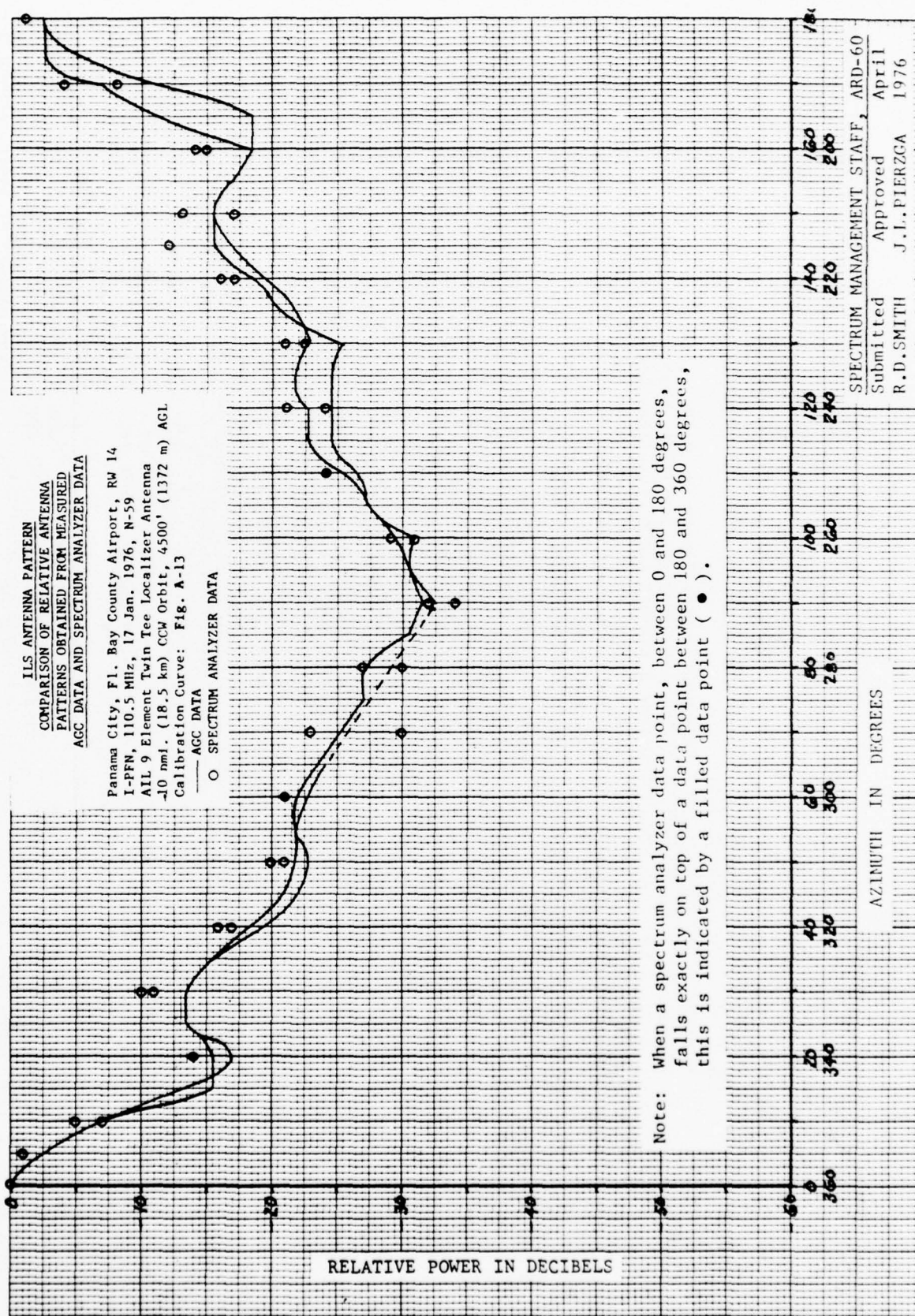


FIGURE B 2

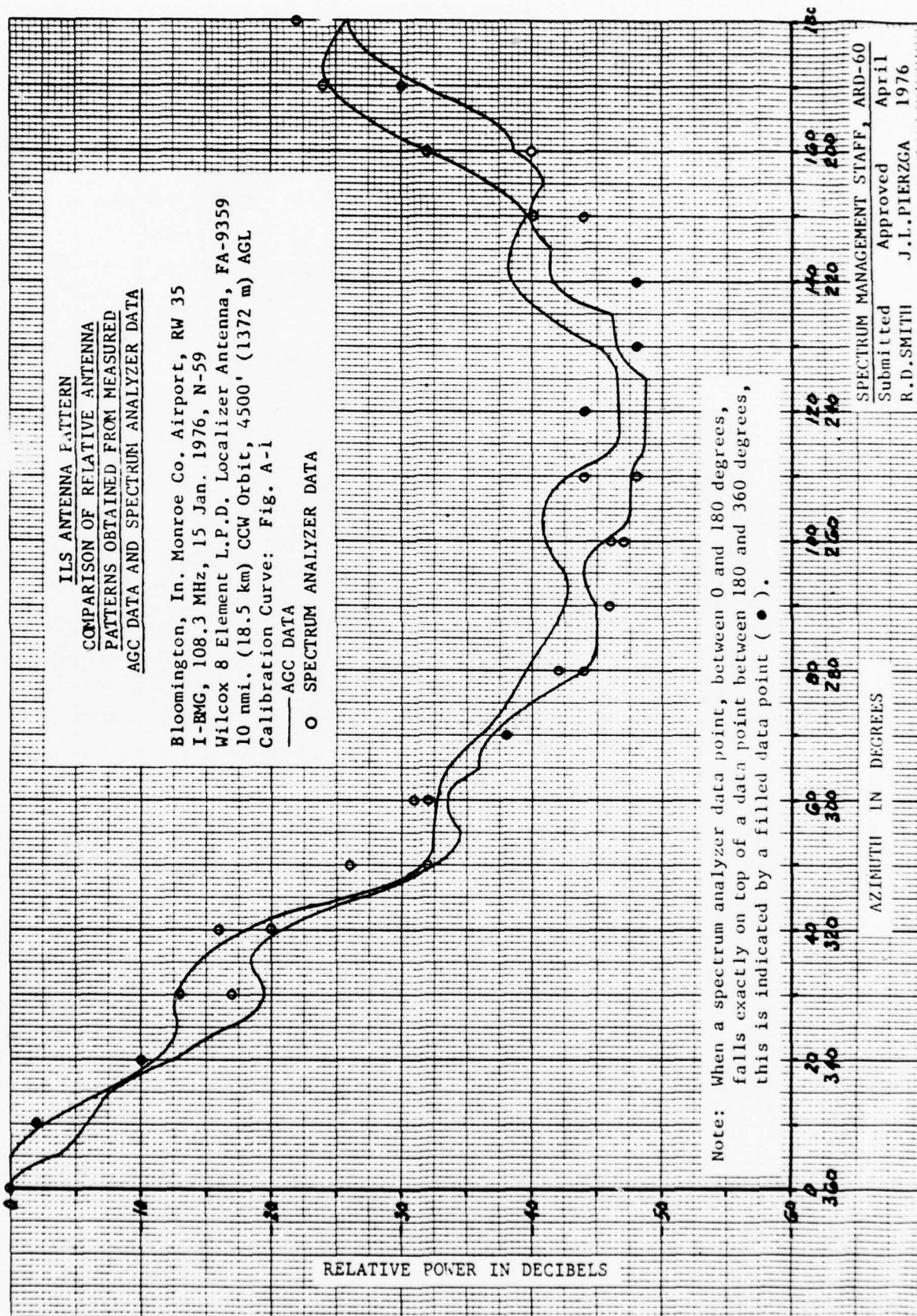
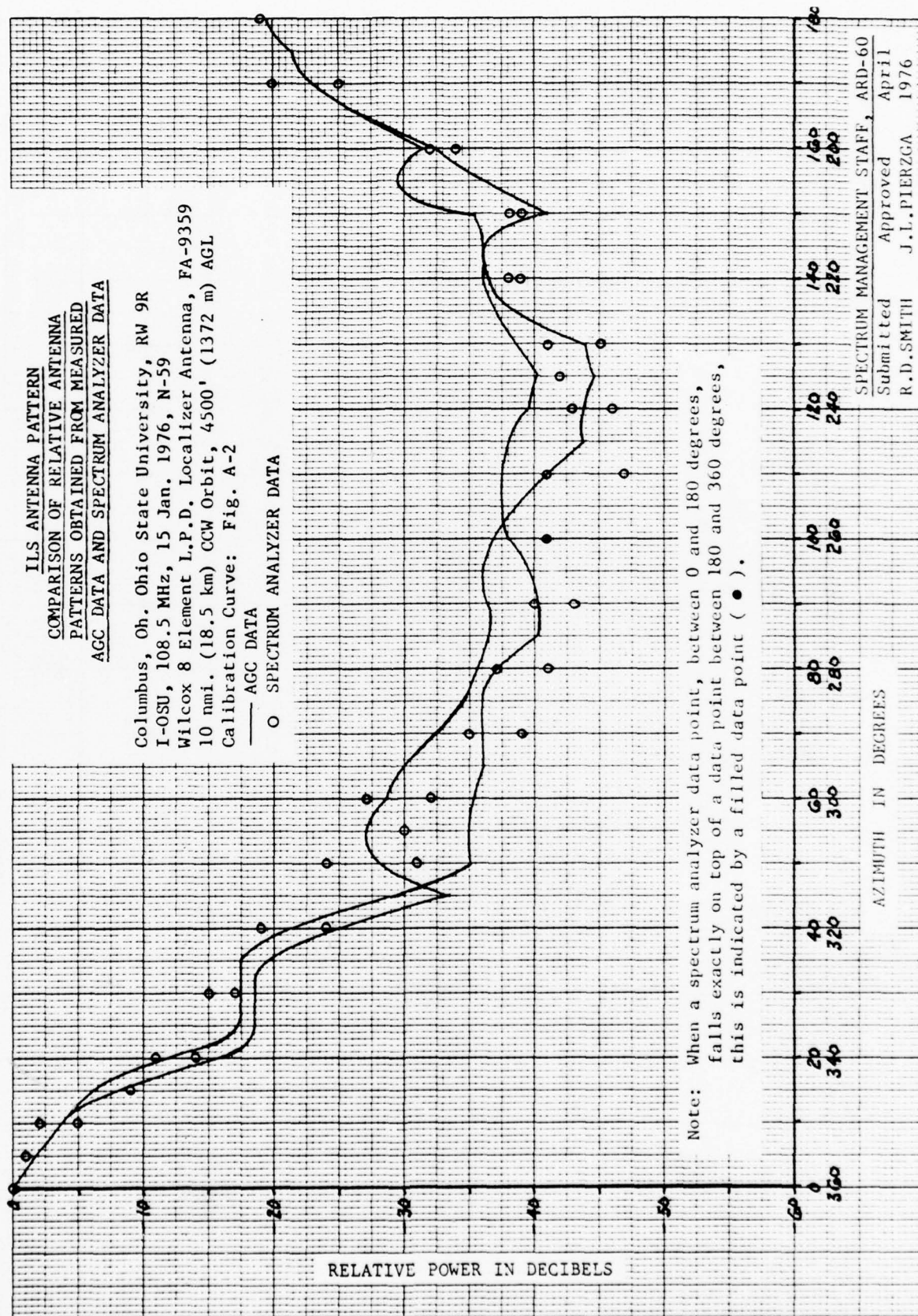


FIGURE B 3

ILS ANTENNA PATTERN
COMPARISON OF RELATIVE ANTENNA
PATTERNS OBTAINED FROM MEASURED
AGC DATA AND SPECTRUM ANALYZER DATA

Columbus, Oh., Ohio State University, RW 9R
I-OSU, 108.5 MHz, 15 Jan. 1976, N-59
Wilcox 8 Element L.P.D. Localizer Antenna, FA-9359
10 nmi. (18.5 km) CCW Orbit, 4500' (1372 m) AGL
Calibration Curve: Fig. A-2

— AGC DATA
O SPECTRUM ANALYZER DATA



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Submitted R.D. SMITH Approved J.L. PIERZGA April 1976

FIGURE B 4

ILS ANTENNA PATTERN
COMPARISON OF RELATIVE ANTENNA
PATTERNS OBTAINED FROM MEASURED
AGC DATA AND SPECTRUM ANALYZER DATA

Altus, Oklahoma, Altus AFB, RW 35
 I-LTS, 110.3 MHz, 29 Jan. 1976, N-59
 MRN-7 Localizer Antenna
 10 nmi. (18.5 km) CCW Orbit, 4500' (1372 m) AGL
 Calibration Curve: Fig. A-12

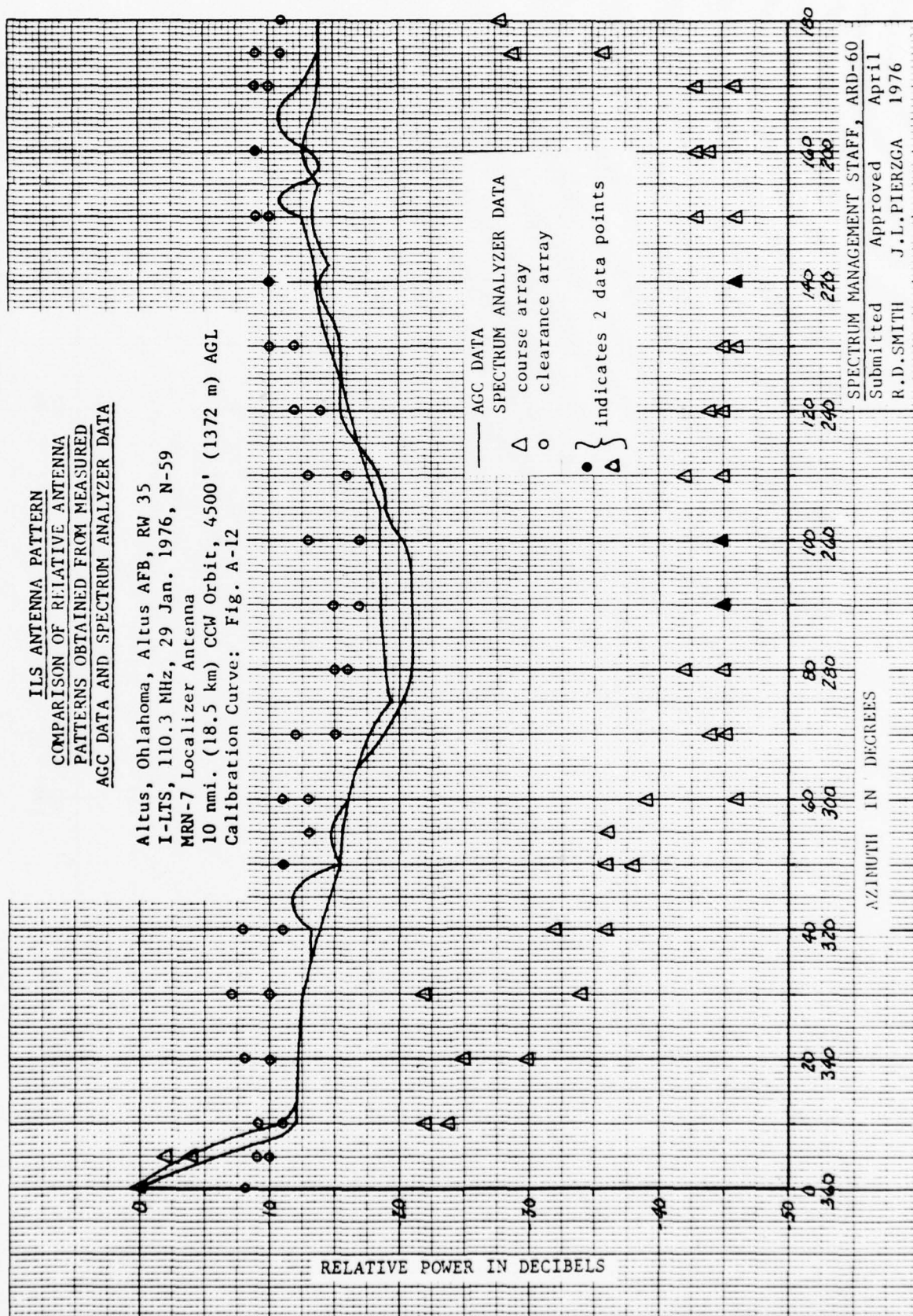


FIGURE B 5

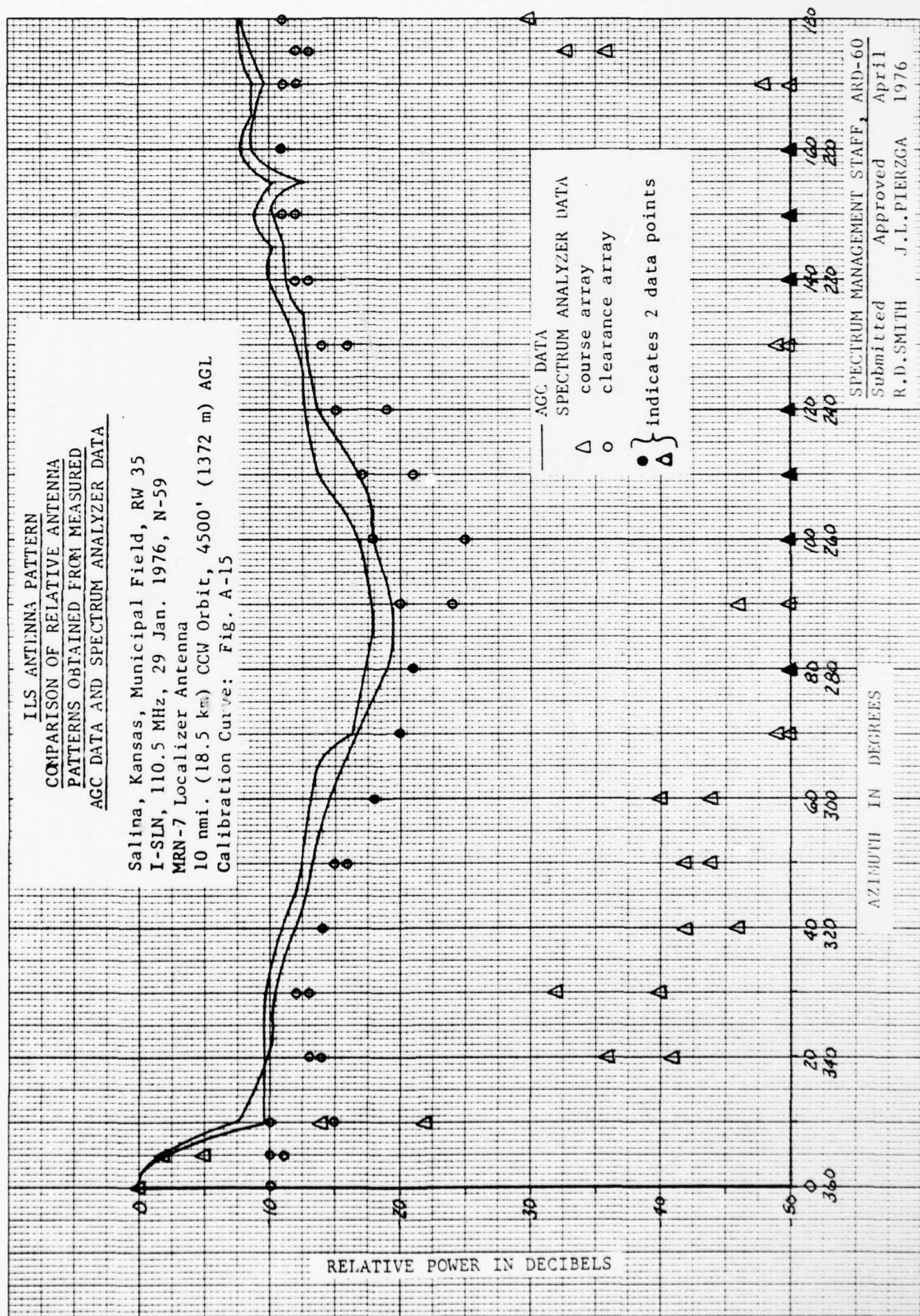


FIGURE B 6

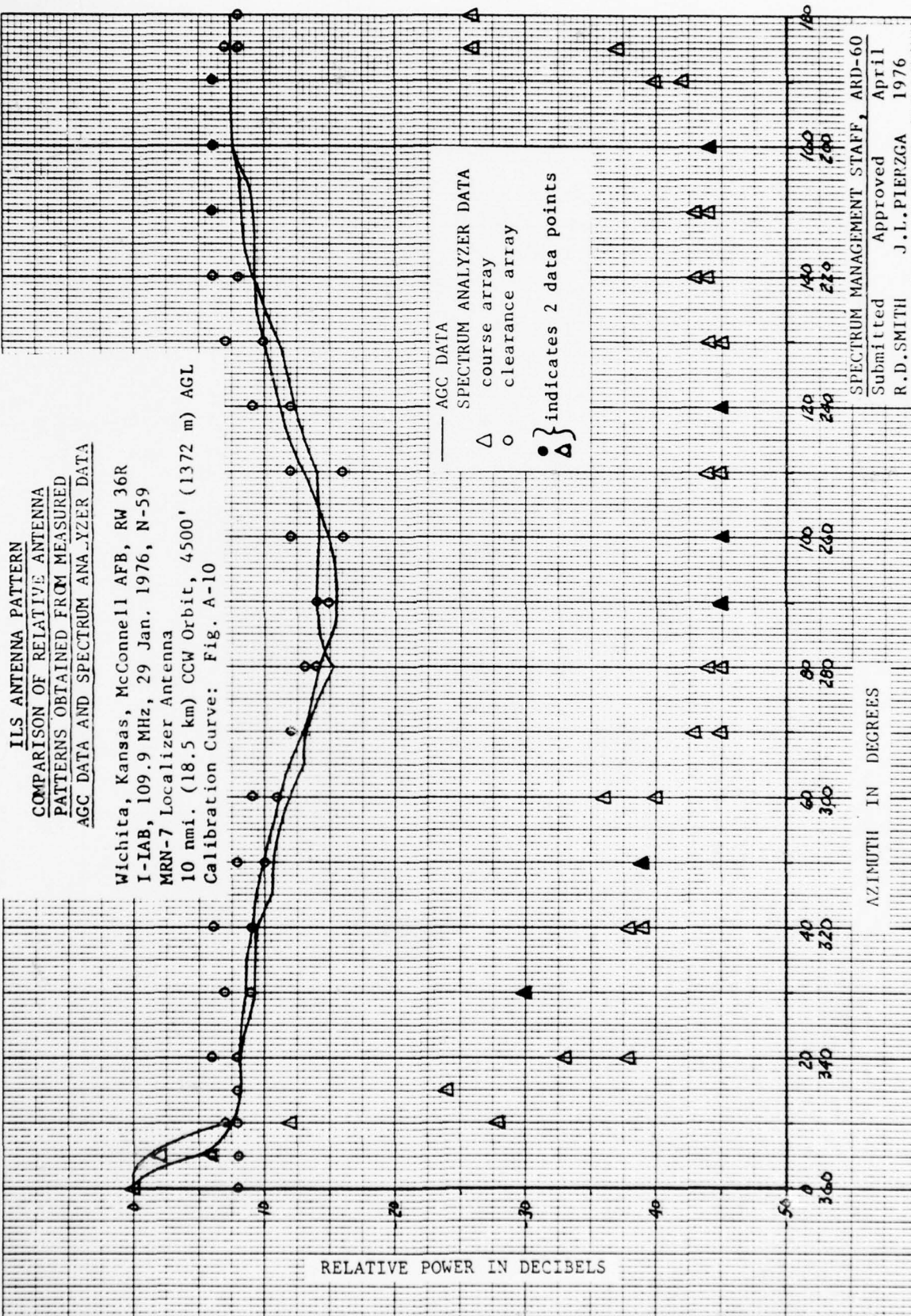


FIGURE B 7

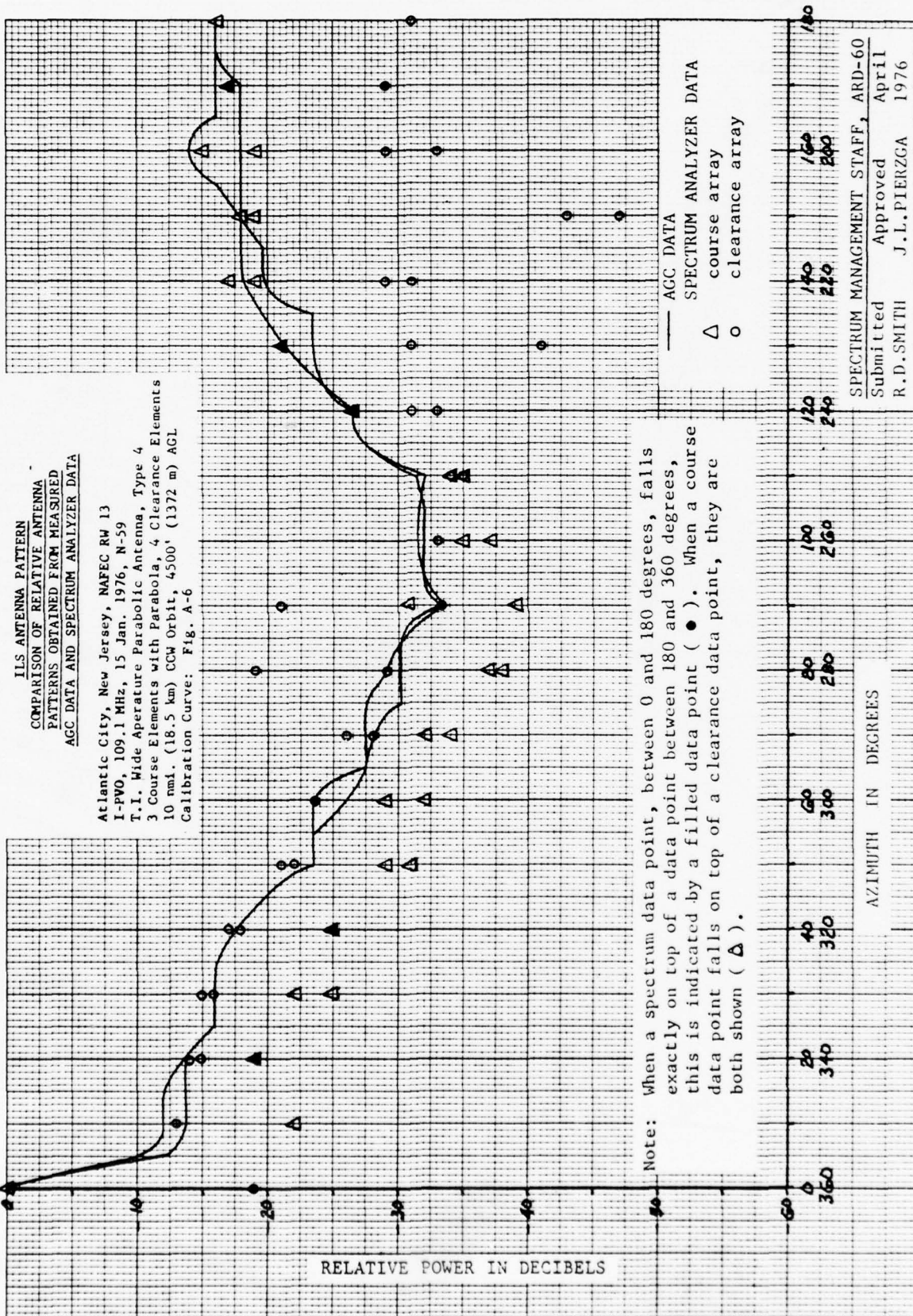


FIGURE B 8

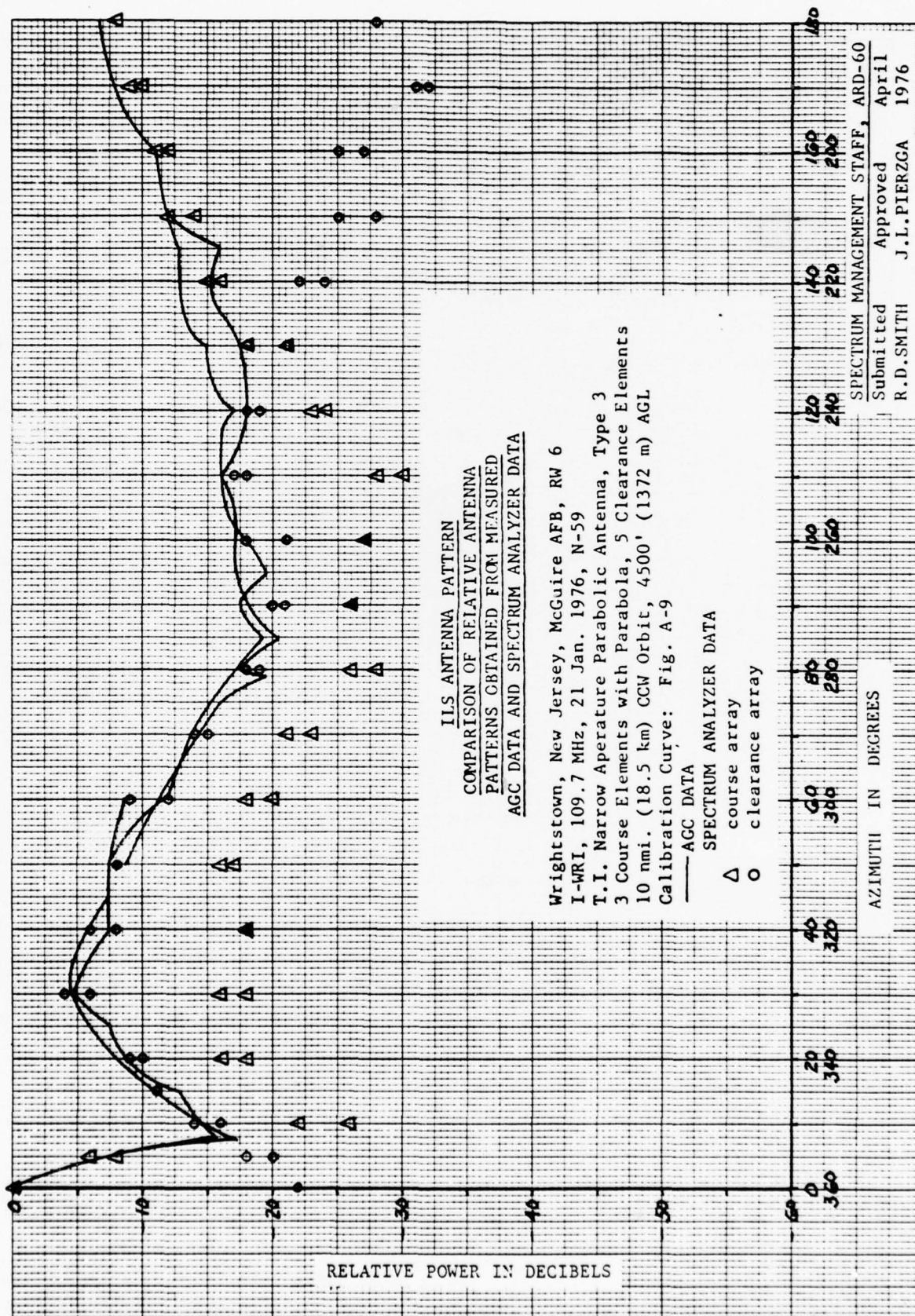


FIGURE B 9

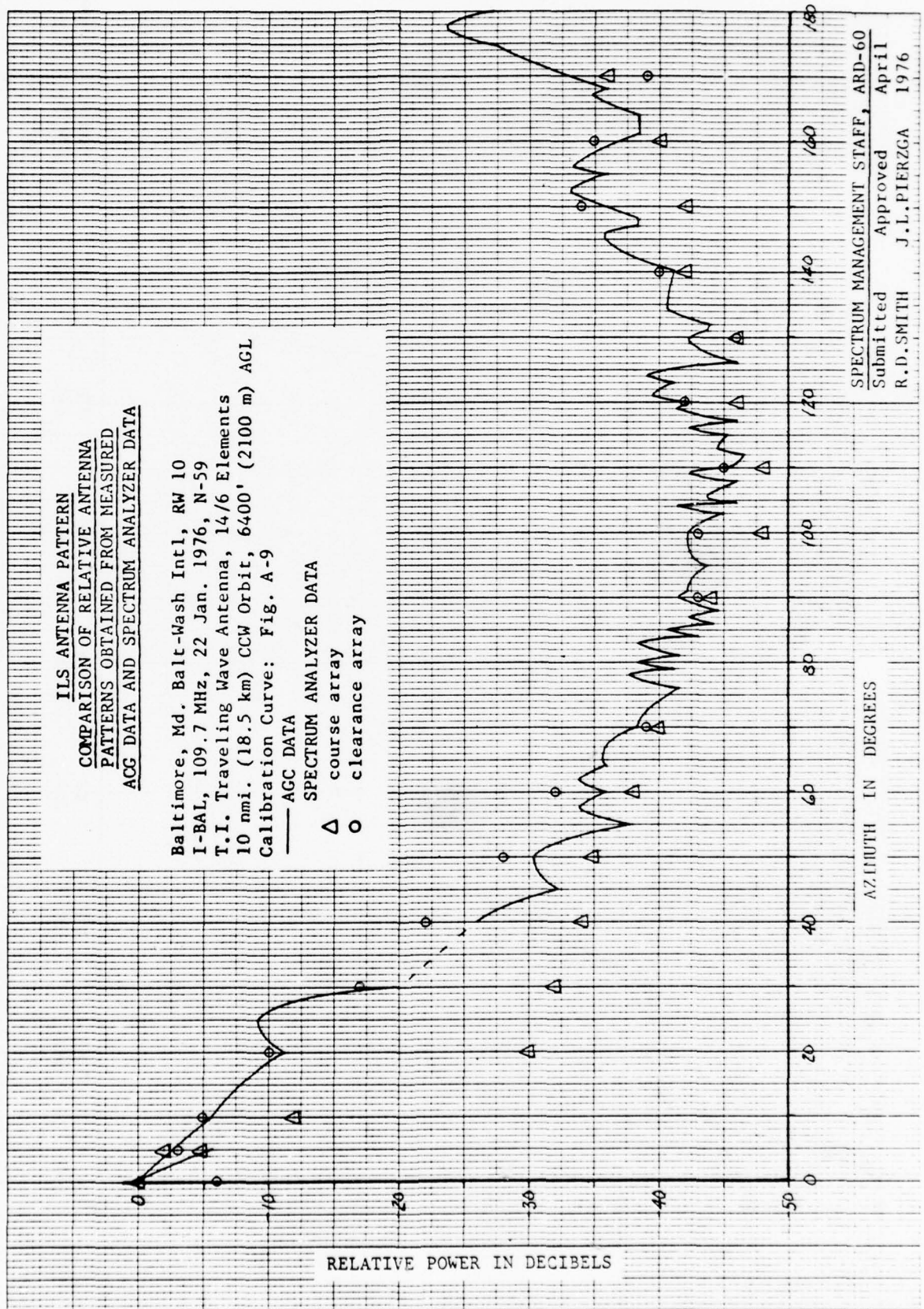


FIGURE B 10

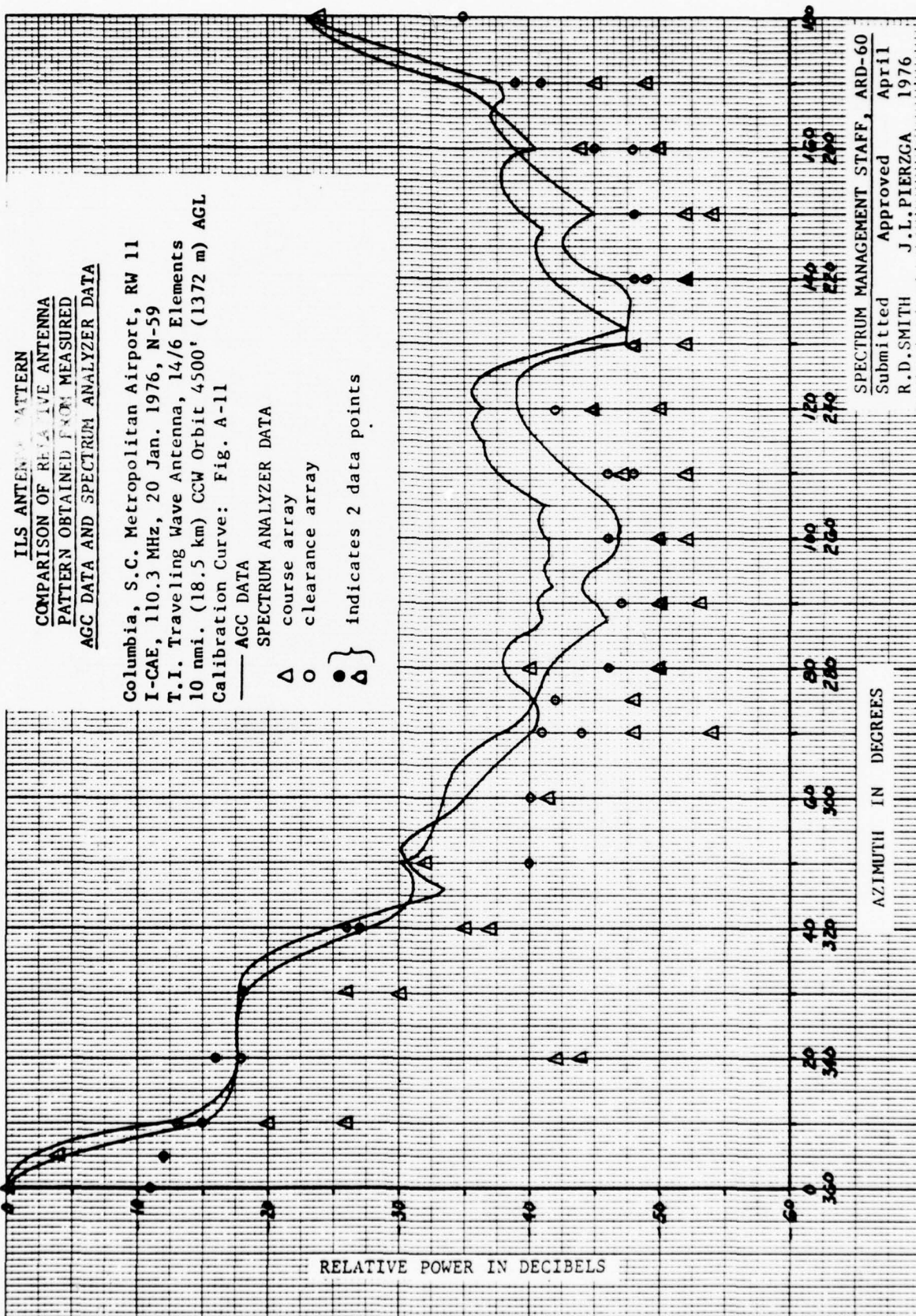


FIGURE B 11

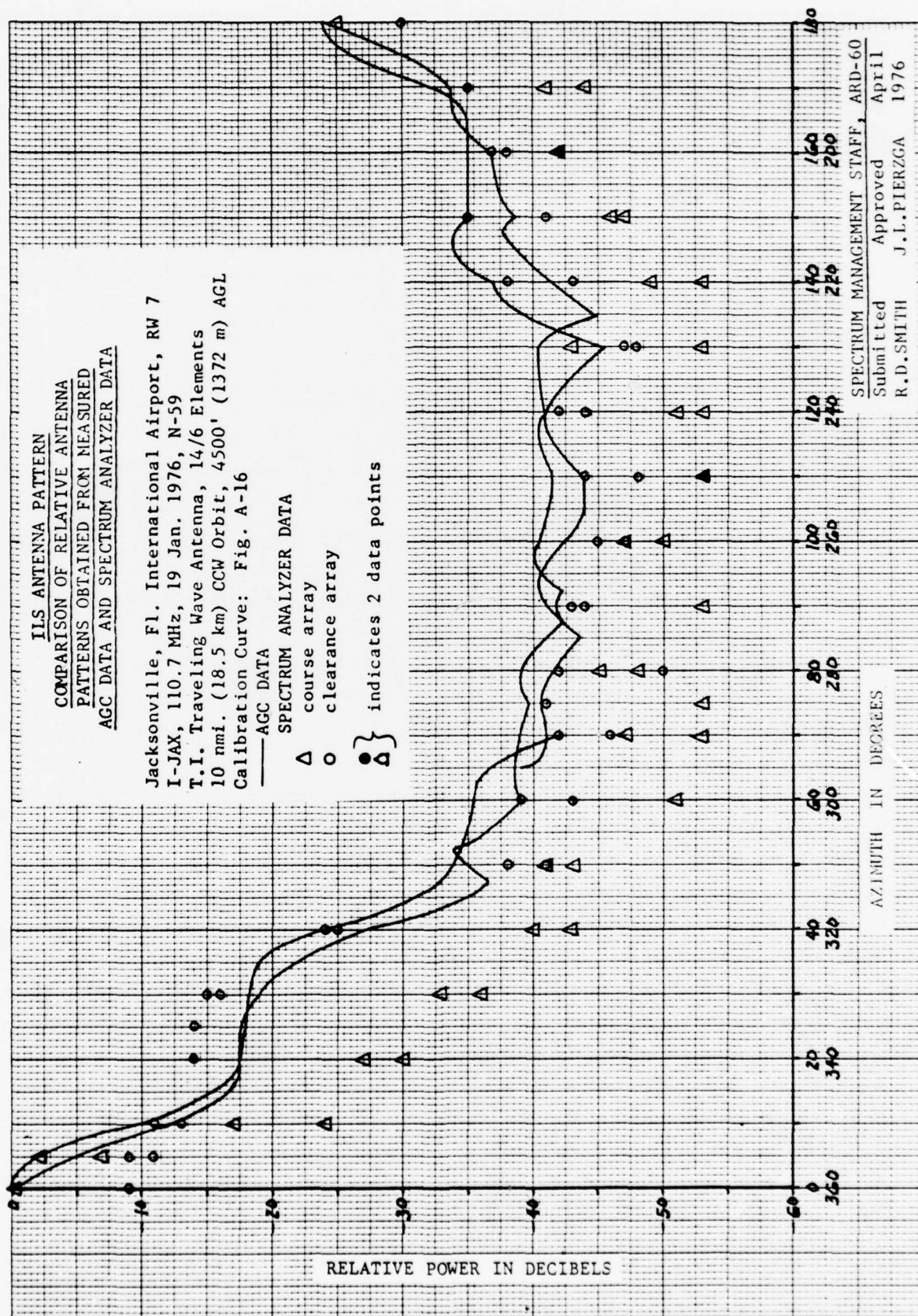


FIGURE B 12

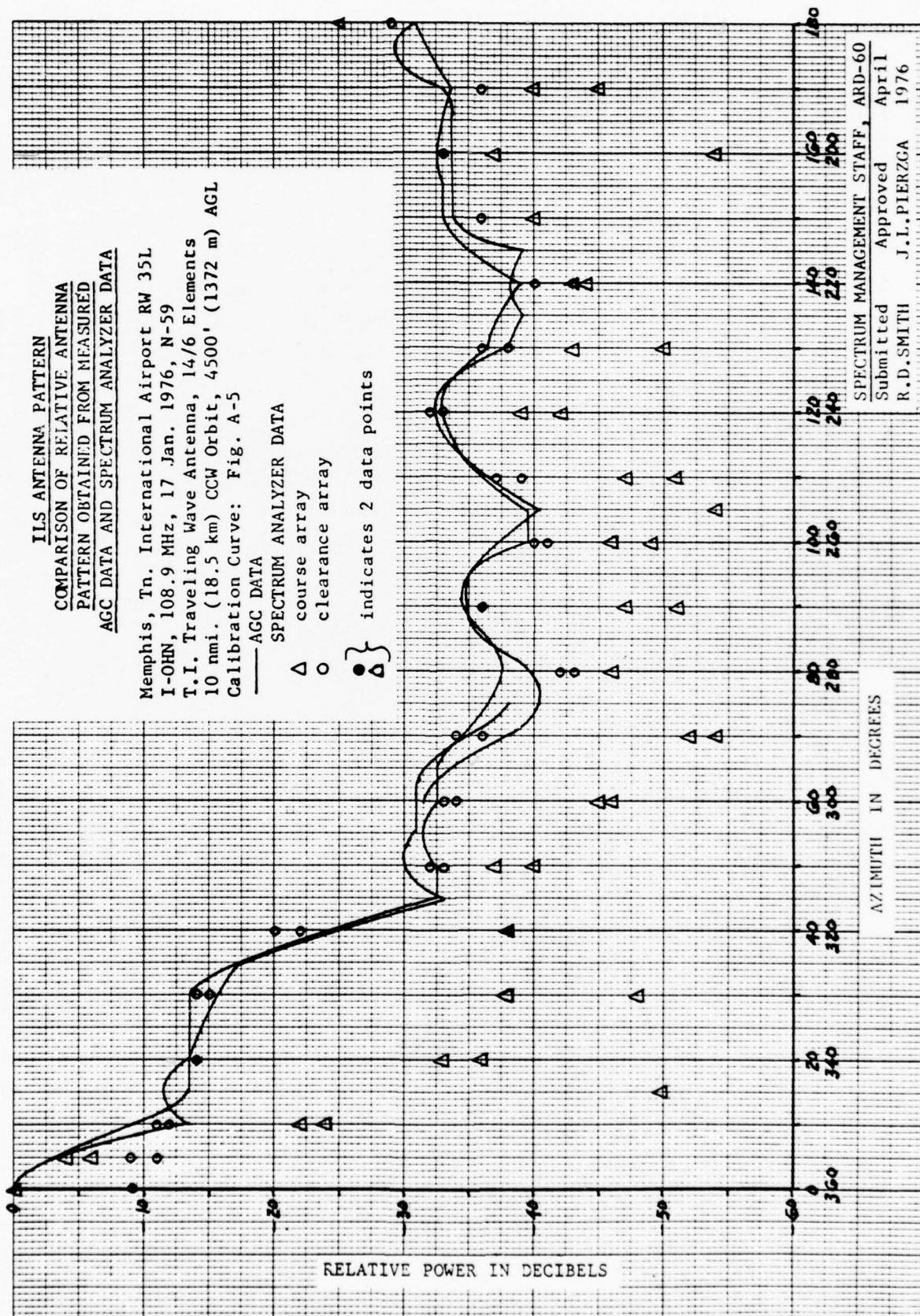


FIGURE E 13

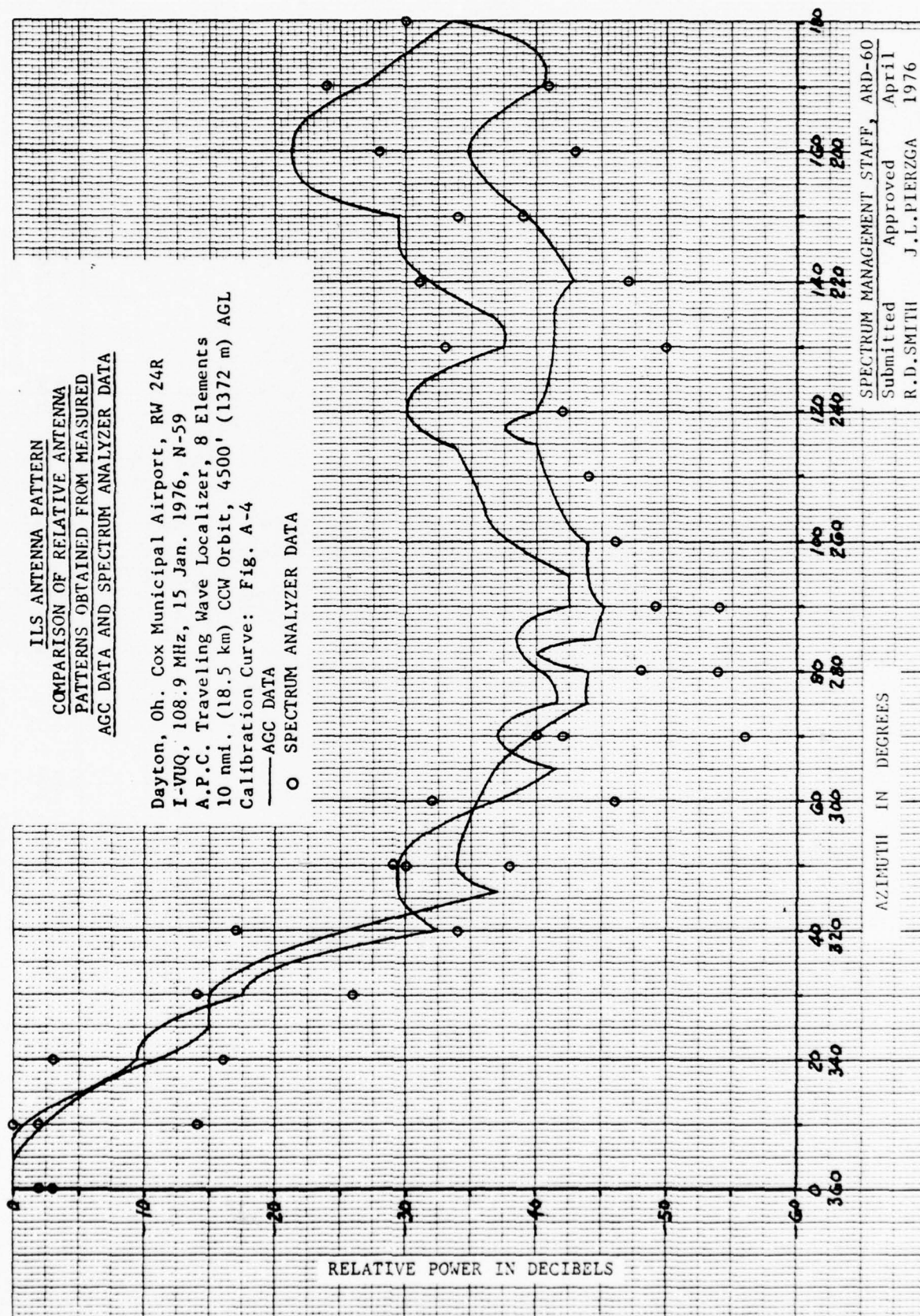


FIGURE B 14

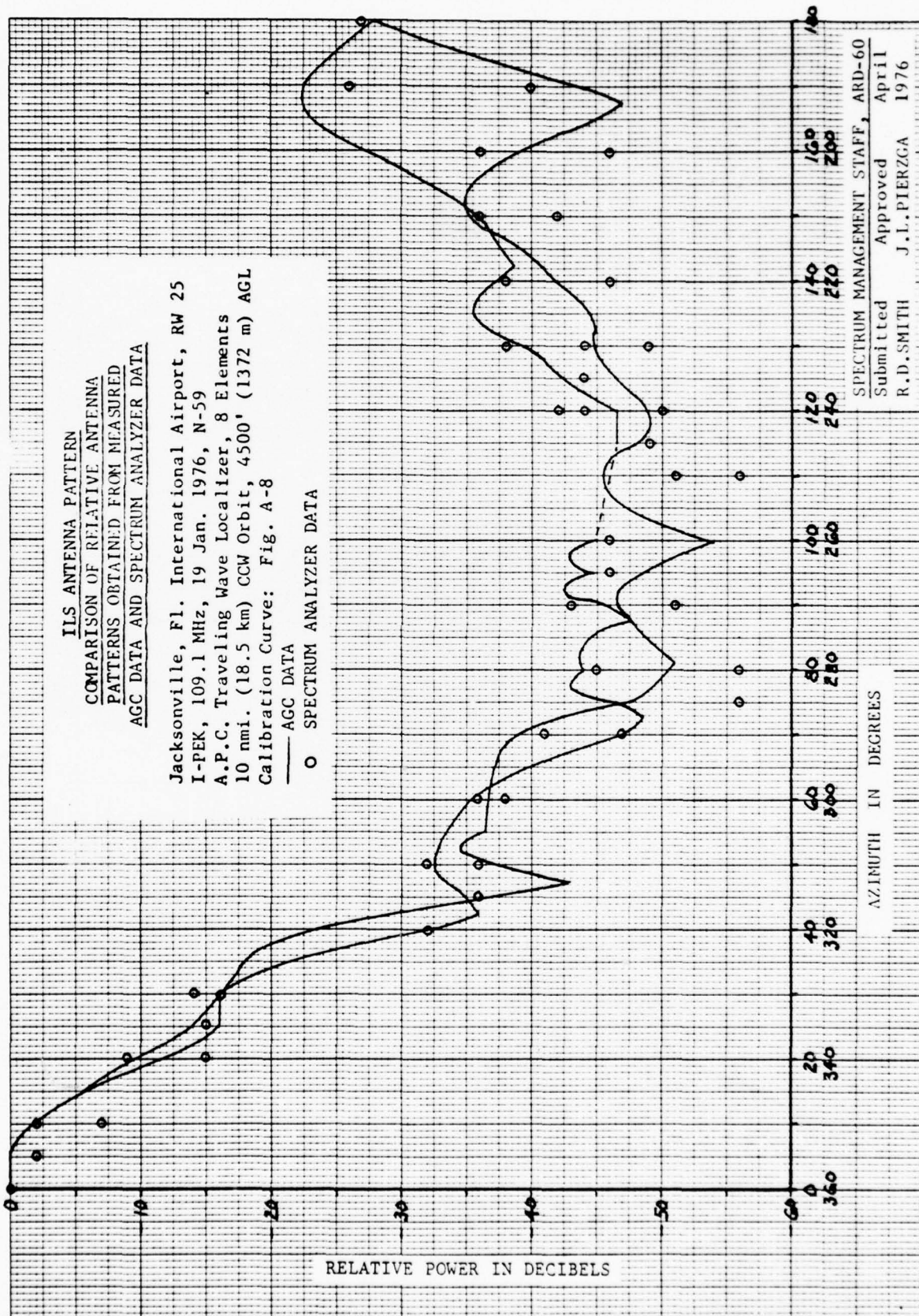
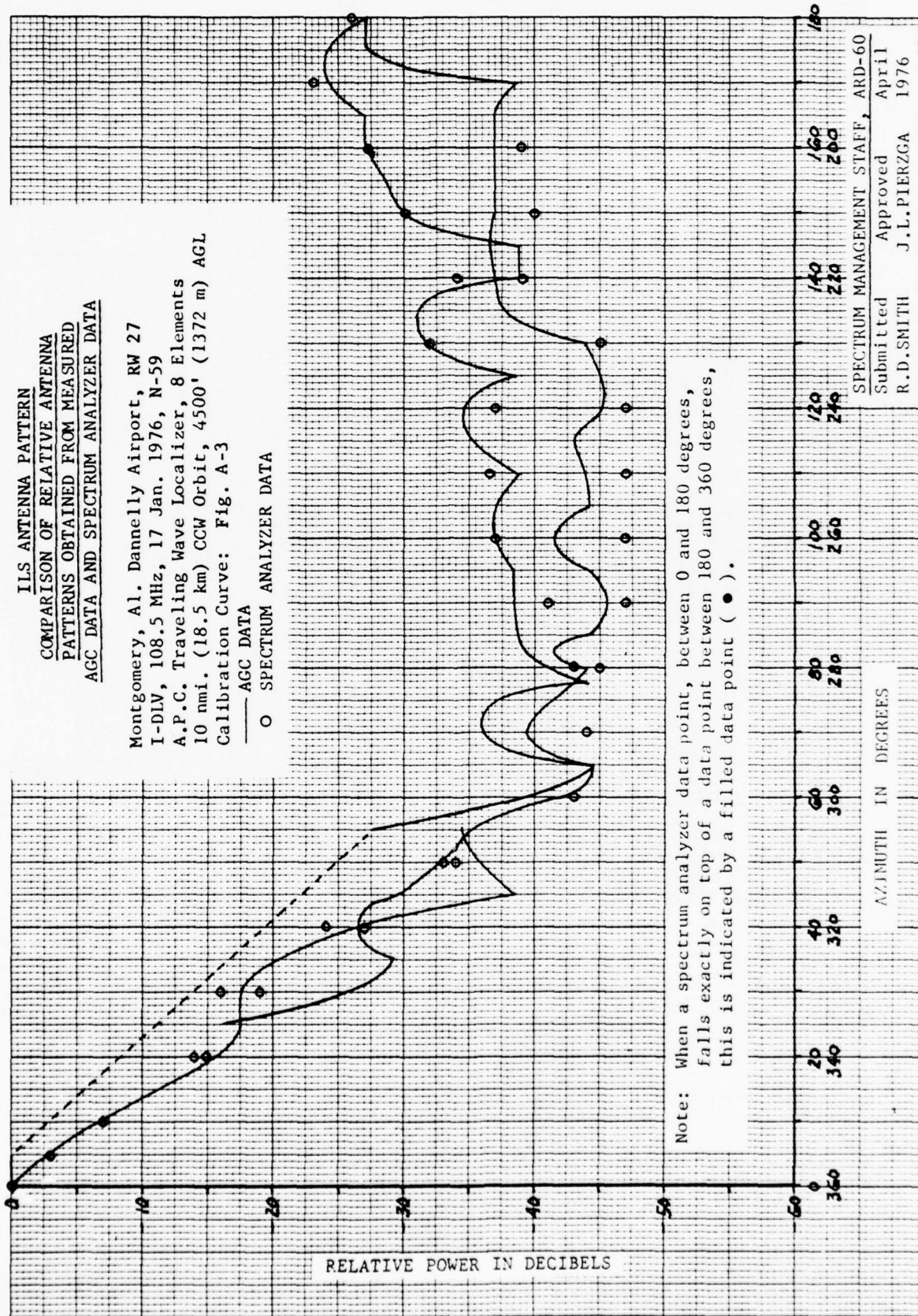


FIGURE B 15

ILS ANTENNA PATTERN
COMPARISON OF RELATIVE ANTENNA
PATTERNS OBTAINED FROM MEASURED
AGC DATA AND SPECTRUM ANALYZER DATA

Montgomery, Al. Dannelly Airport, RW 27
I-DLV, 108.5 MHz, 17 Jan. 1976, N-59
A.P.C. Traveling Wave Localizer, 8 Elements
10 nmi. (18.5 km) CCW Orbit, 4500' (1372 m) AGL
Calibration Curve: Fig. A-3

— AGC DATA
O SPECTRUM ANALYZER DATA



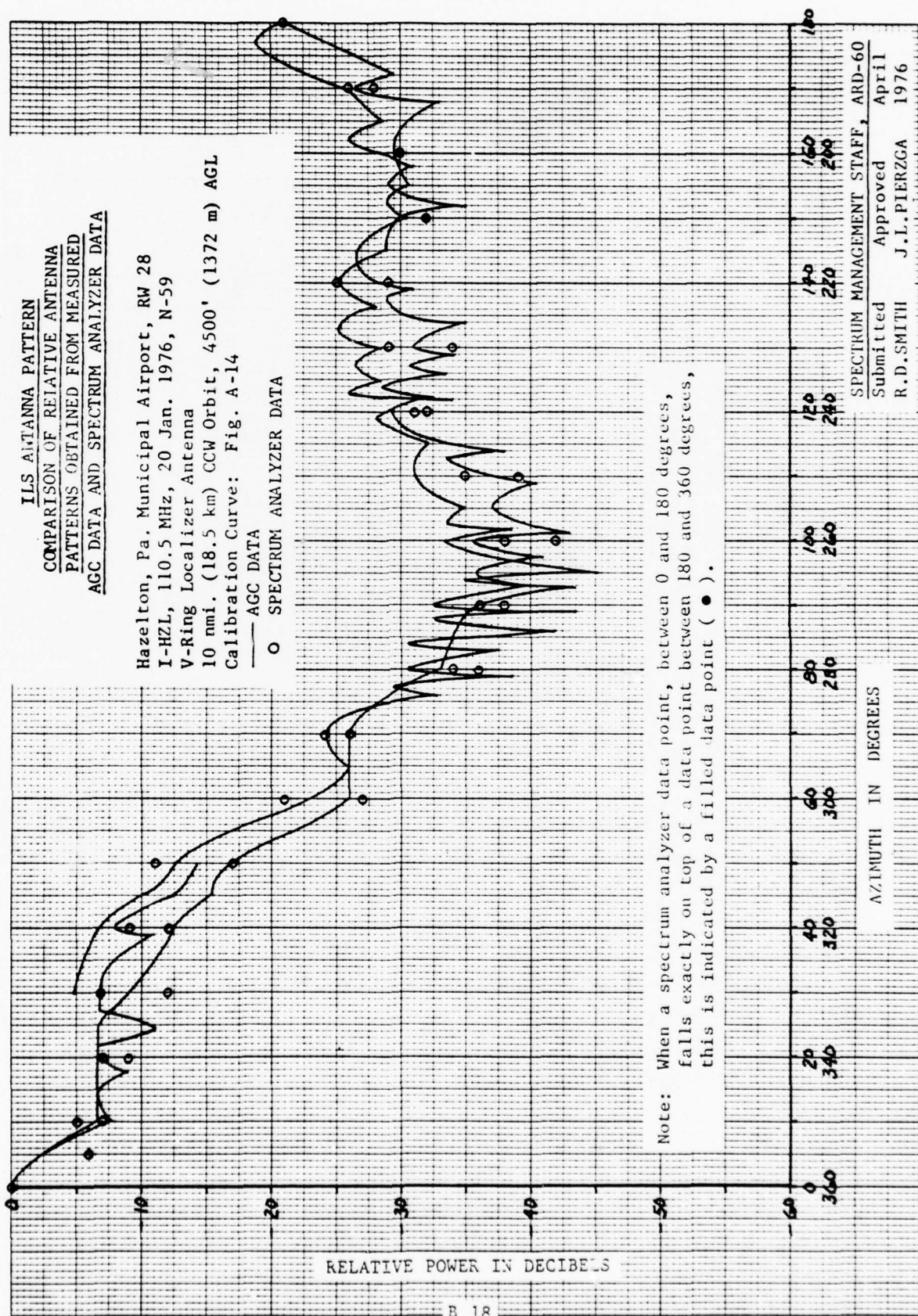
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Submitted R.D. SMITH
Approved J.L. PIERZGA
April 1976

FIGURE B 16

ILS ALTIANNA PATTERN
COMPARISON OF RELATIVE ANTENNA
PATTERNS OBTAINED FROM MEASURED
AGC DATA AND SPECTRUM ANALYZER DATA

Hazelton, Pa. Municipal Airport, RW 28
I-HZL, 110.5 MHz, 20 Jan. 1976, N-59
V-Ring Localizer Antenna
10 nmi. (18.5 km) CCW Orbit, 4500' (1372 m) AGL
Calibration Curve: Fig. A-14

— AGC DATA
O SPECTRUM ANALYZER DATA



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Submitted R.D.SMITH Approved J.L.PIERZGA April 1976

FIGURE B 17

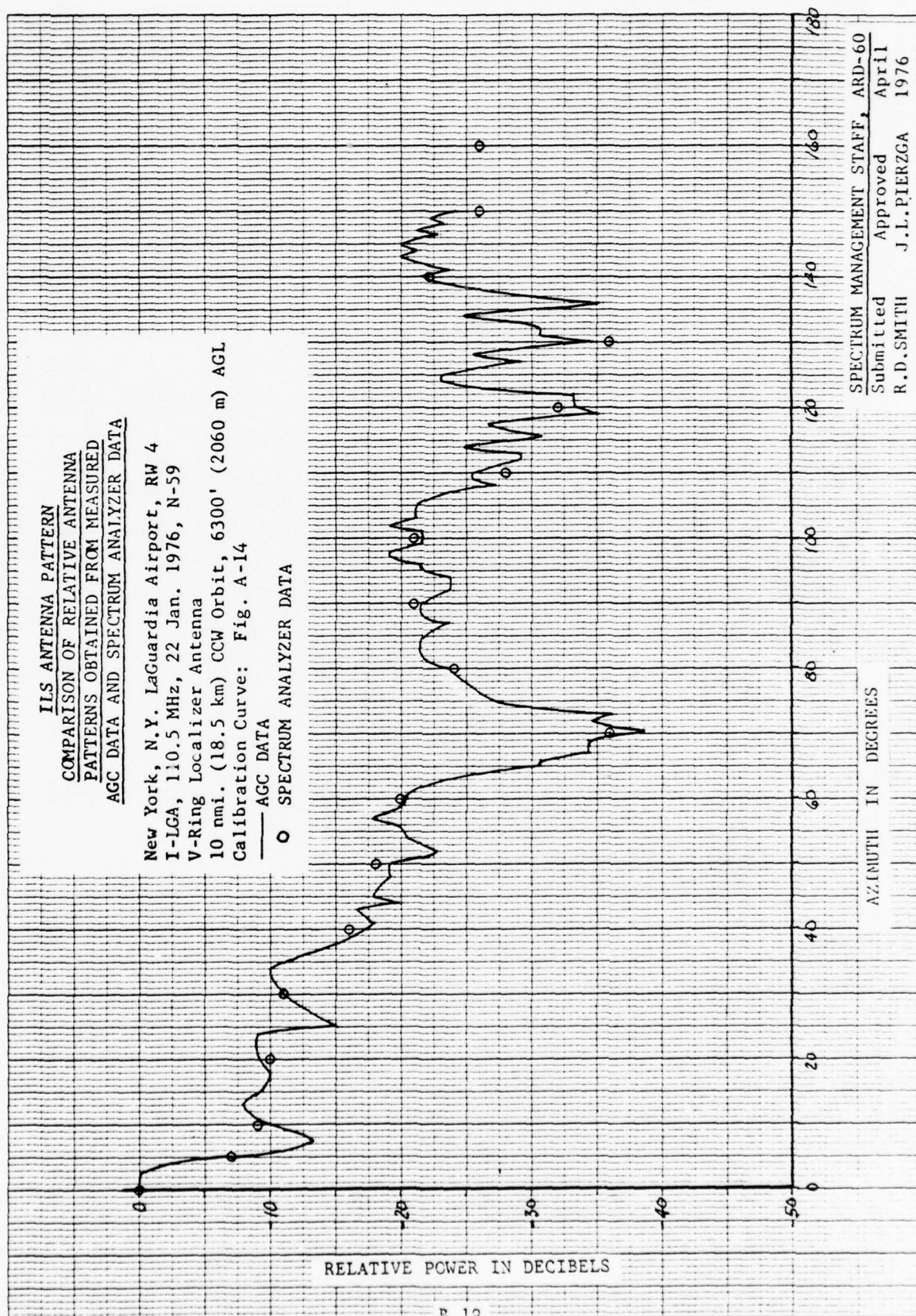


FIGURE B 18

ILS ANTENNA PATTERN
COMPARISON OF RELATIVE ANTENNA
PATTERNS OBTAINED FROM MEASURED
AGC DATA AND SPECTRUM ANALYZER DATA

Chantilly, Va. Dulles Airport, RW 19R
 I-DLX, 111.3 MHz, 16 Jan. 1976, N-59
 Waveguide Localizer Antenna
 10 nmi (18.5 km) CCW Orbit, 4500' (1372 m) AGL
 Calibration Curve: Fig. A-18

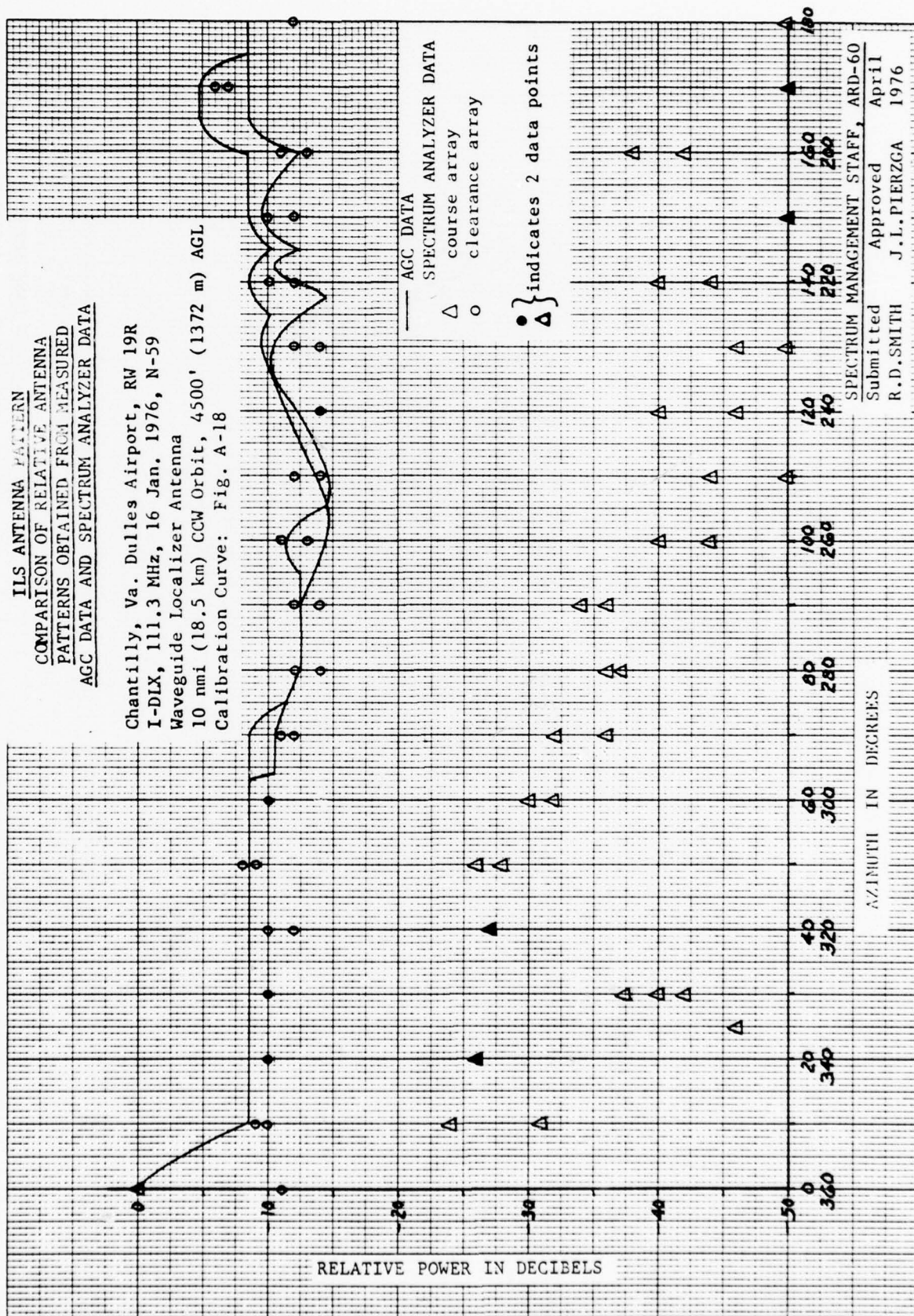


FIGURE B 19

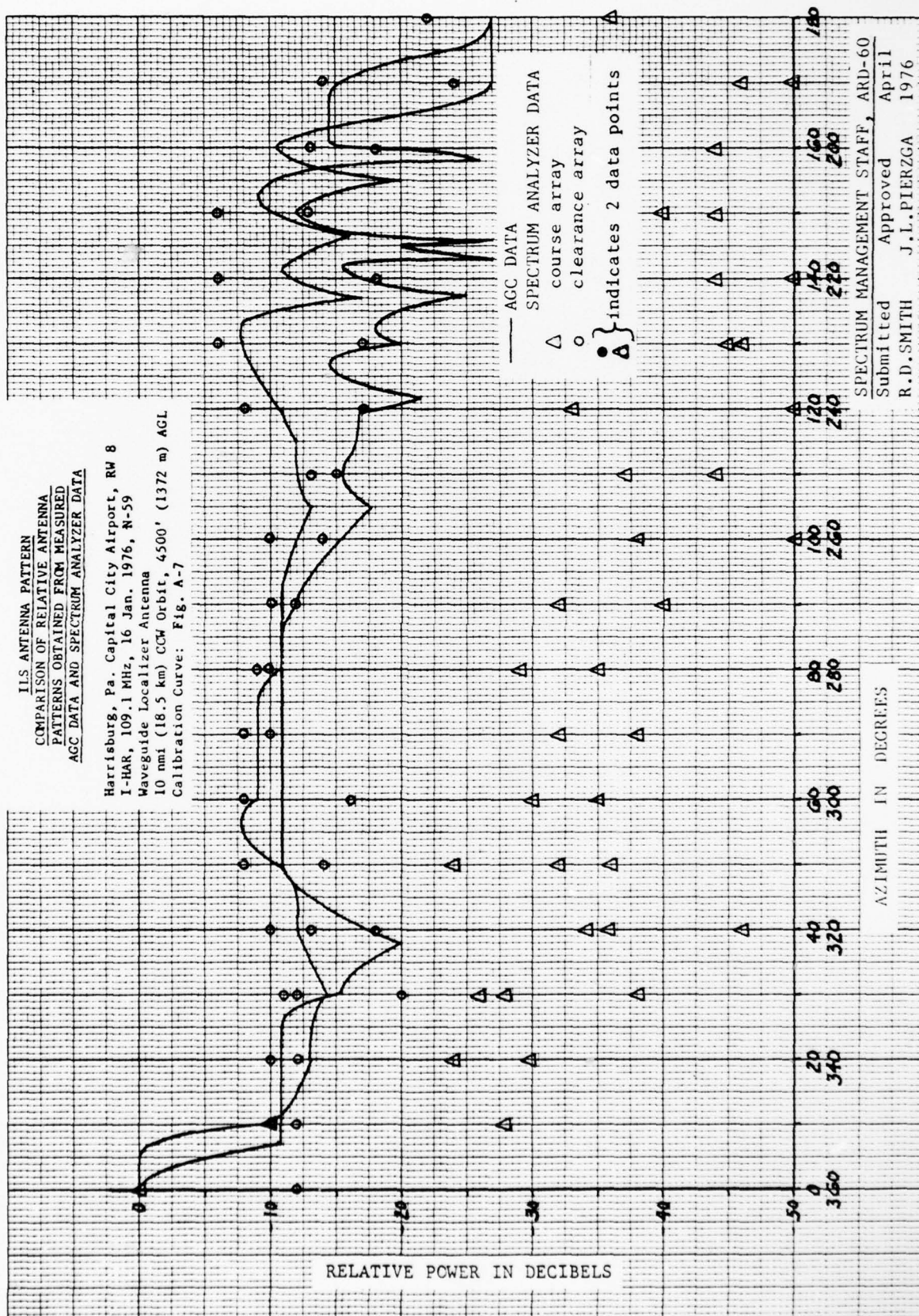


FIGURE B 20

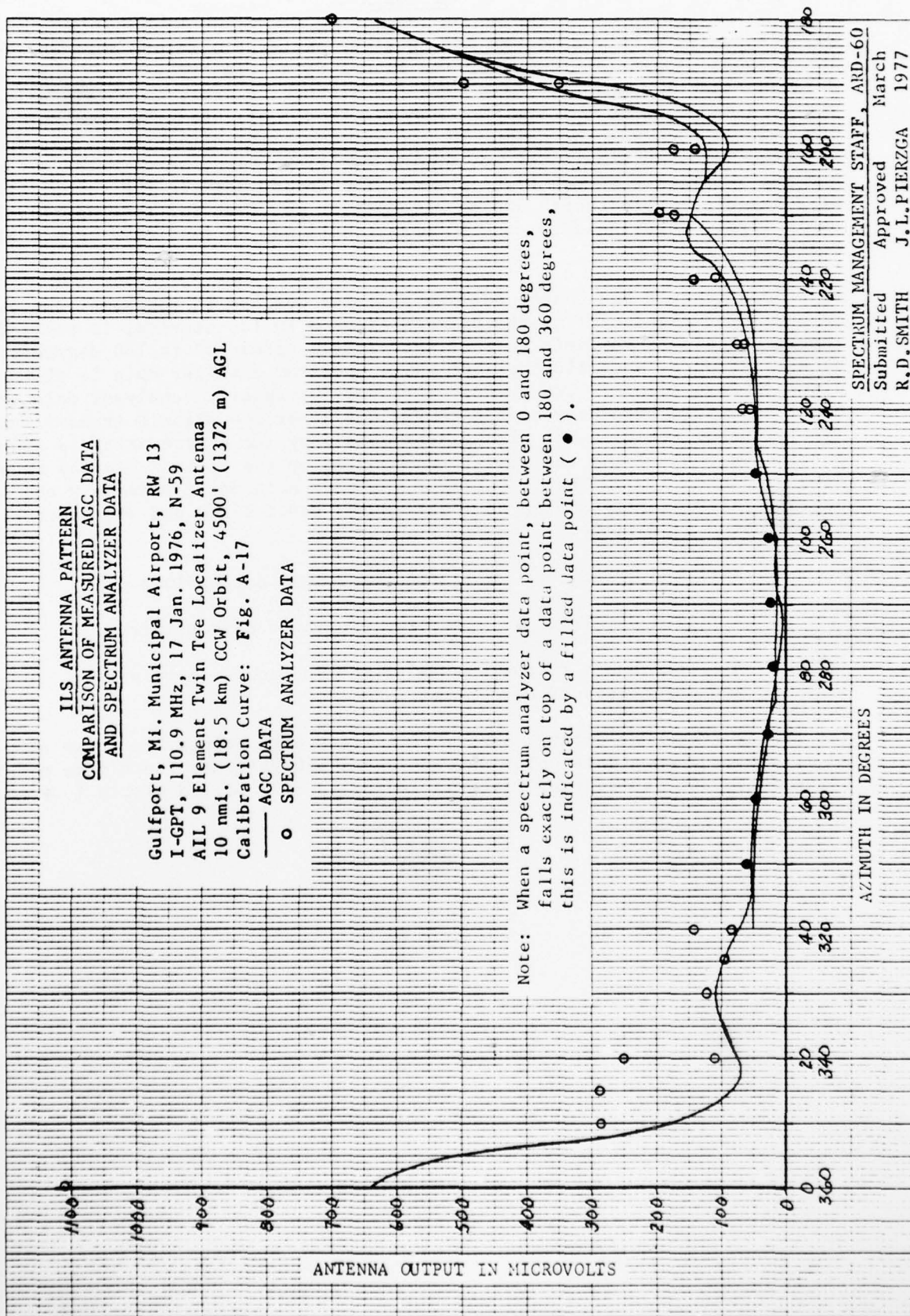
APPENDIX C

While Appendix B only compared the relative patterns obtained through the two methods, Appendix C compares the actual data. In order to do this, AGC data and spectrum analyzer data were transformed in order to obtain values at the same point in the system. Since both methods used the same antenna, the point chosen was the output of the antenna. The data transformations required to do this involved accounting for line losses between the antenna and the respective pieces of hardware. The losses used in the calculations were based on cable length and on attenuation per foot for that particular cable type. Unfortunately, these losses could not be confirmed by actual measurements.

Both Appendixes B and C show antenna patterns graphed in the same general manner. The right half of the pattern (from 0 to 180 degrees) is plotted on the same scale as the left half of the pattern (from 360 to 180 degrees). AGC data is shown as a continuous line while spectrum analyzer data is shown as discrete data points. Two symbols are used for spectrum analyzer data in order to distinguish between the course and clearance signals transmitted by two frequency arrays. The signal transmitted by the course array is shown as a triangle (Δ) and the signal transmitted by the clearance array is shown as a circle (\circ). When a spectrum analyzer data point between 0 and 180 degrees falls exactly on top of a data point between 180 and 360 degrees, this is indicated as follows:

1. A filled triangle (\blacktriangle) for two course data points.
2. A filled circle (\bullet) for two clearance data points.
3. A circle and a triangle ($\Delta \circ$) for one course data point and one clearance data point.

For single frequency arrays, spectrum analyzer data points are shown simply as circles. When a data point between 0 and 180 falls on top a data point between 180 and 360 degrees, this is indicated by a filled circle (\bullet).



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 Submitted Approved March
 R.D. SMITH J.L. PIERZGA 1977

FIGURE C 1

IIS ANTENNA PATTERN
COMPARISON OF MEASURED AGC DATA
AND SPECTRUM ANALYZER DATA

Panama City, Fl. Bay County Airport, RW 14
I-PFN, 110.5 MHz, 17 Jan. 1976, N-59
AIL 9 Element Twin Tee Localizer Antenna
10 nmi. (18.5 km) CCW Orbit, 4500' (1372 m) AGL
Calibration Curve: Fig. A-13

— AGC DATA
O SPECTRUM ANALYZER DATA

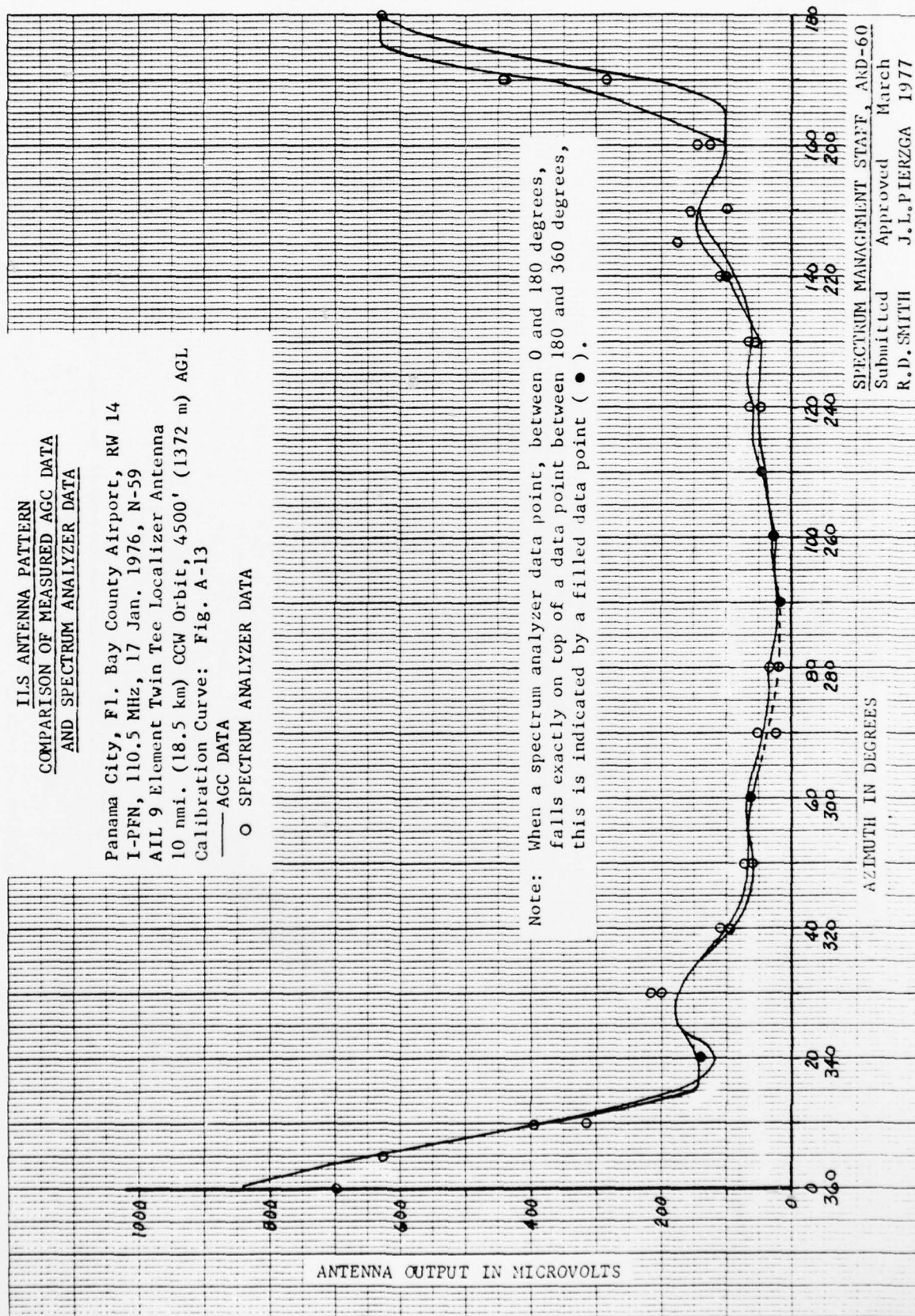


FIGURE C 2

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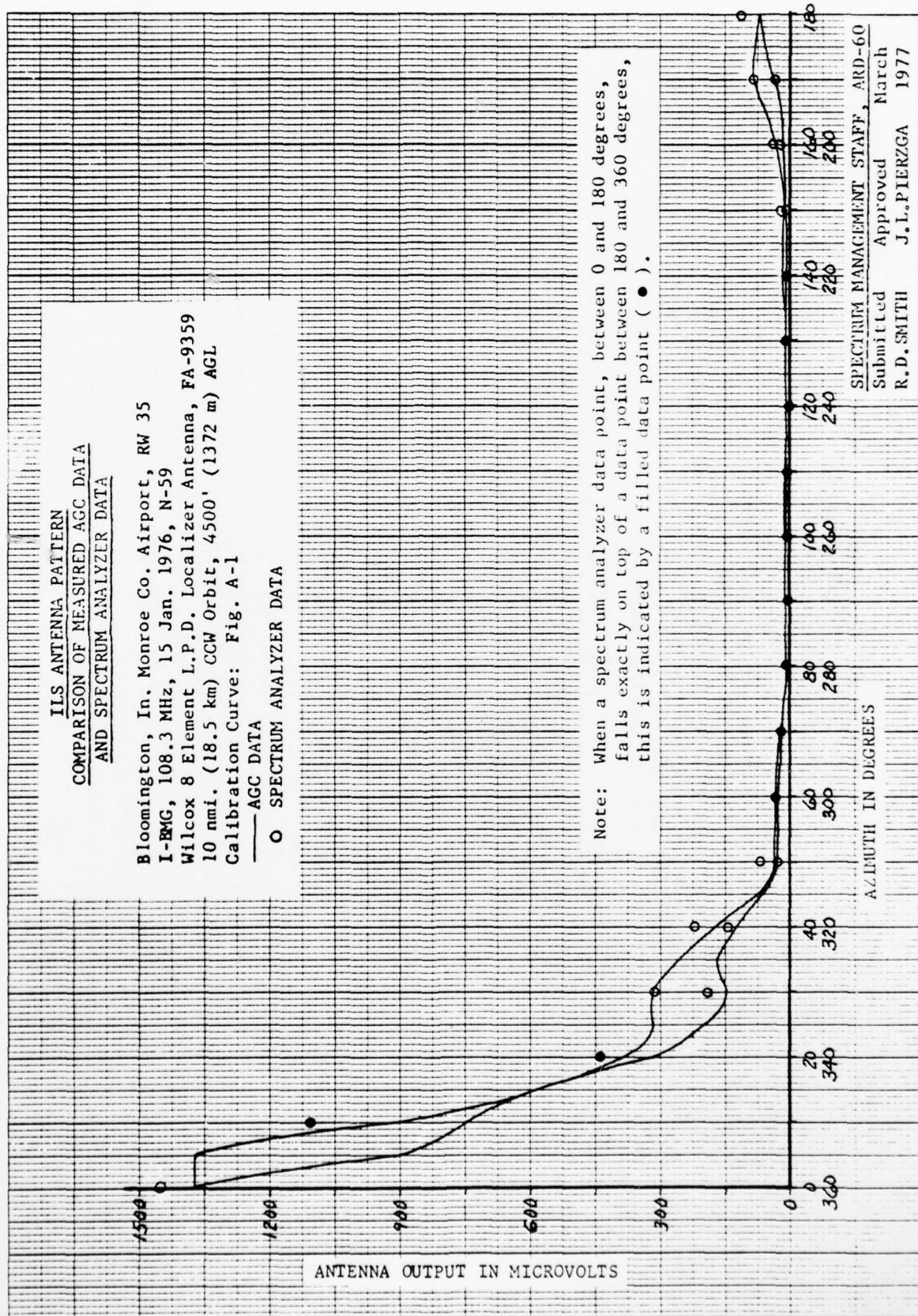


FIGURE C 3

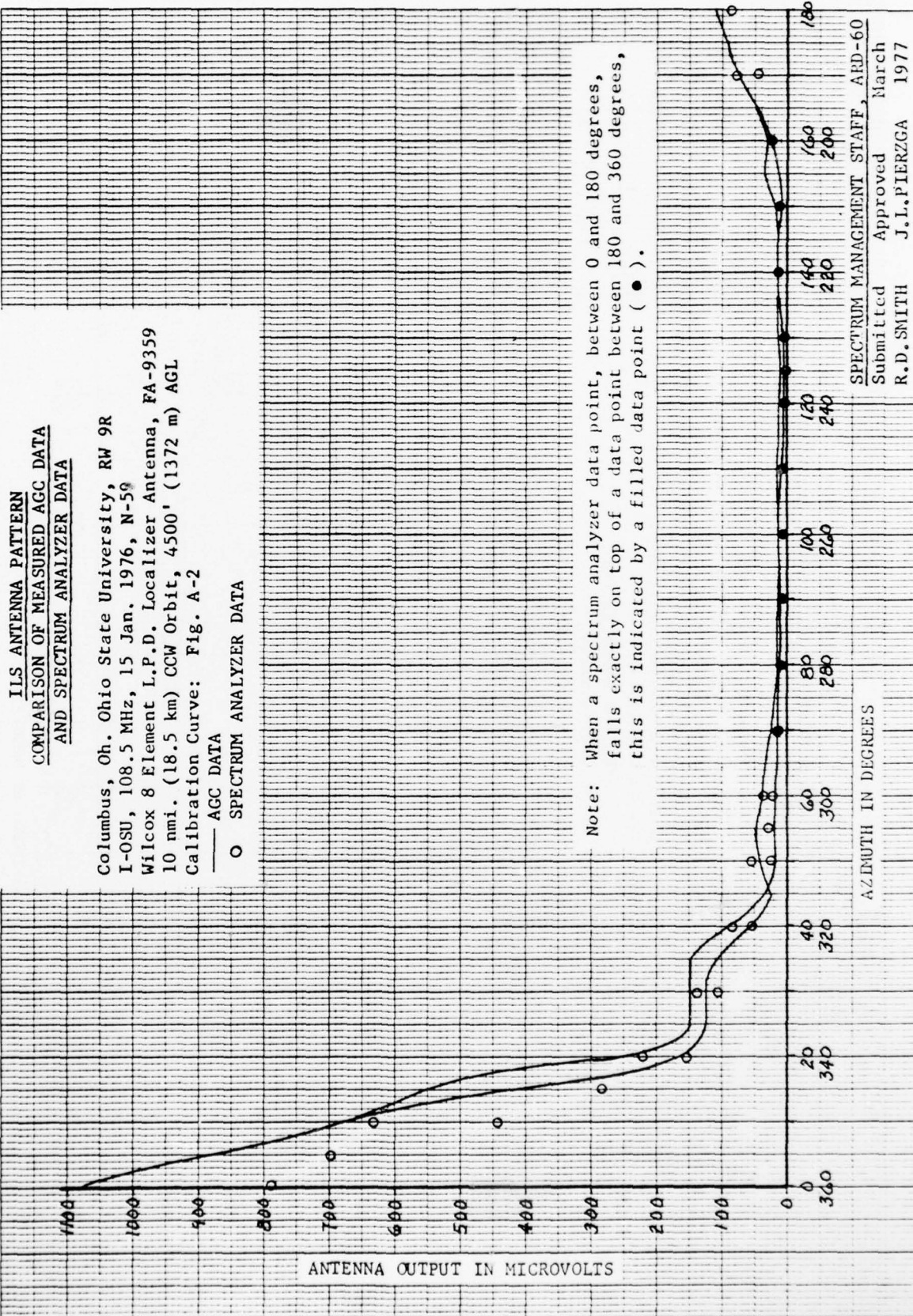


FIGURE C 4

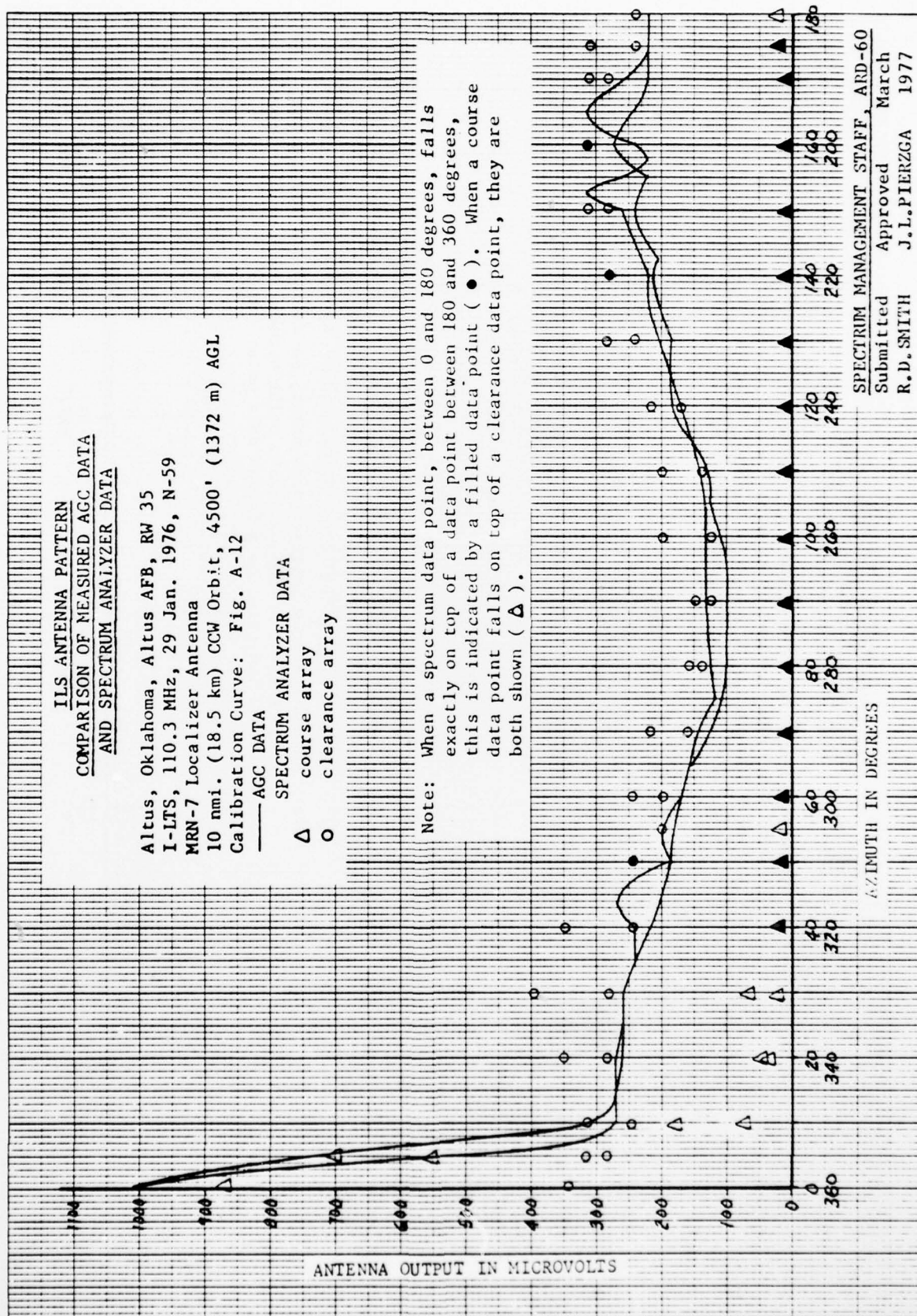


FIGURE C 5

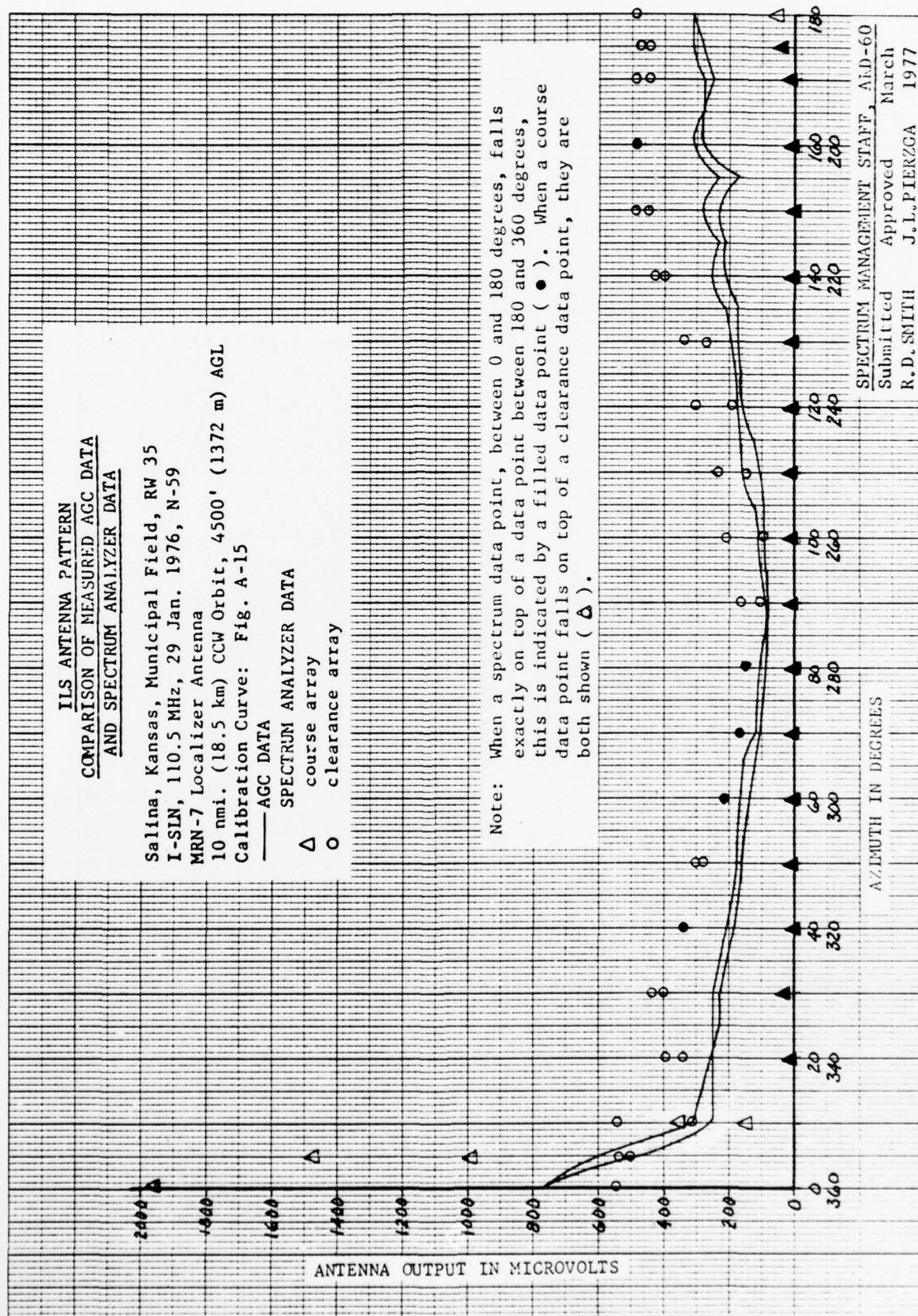


FIGURE C 6

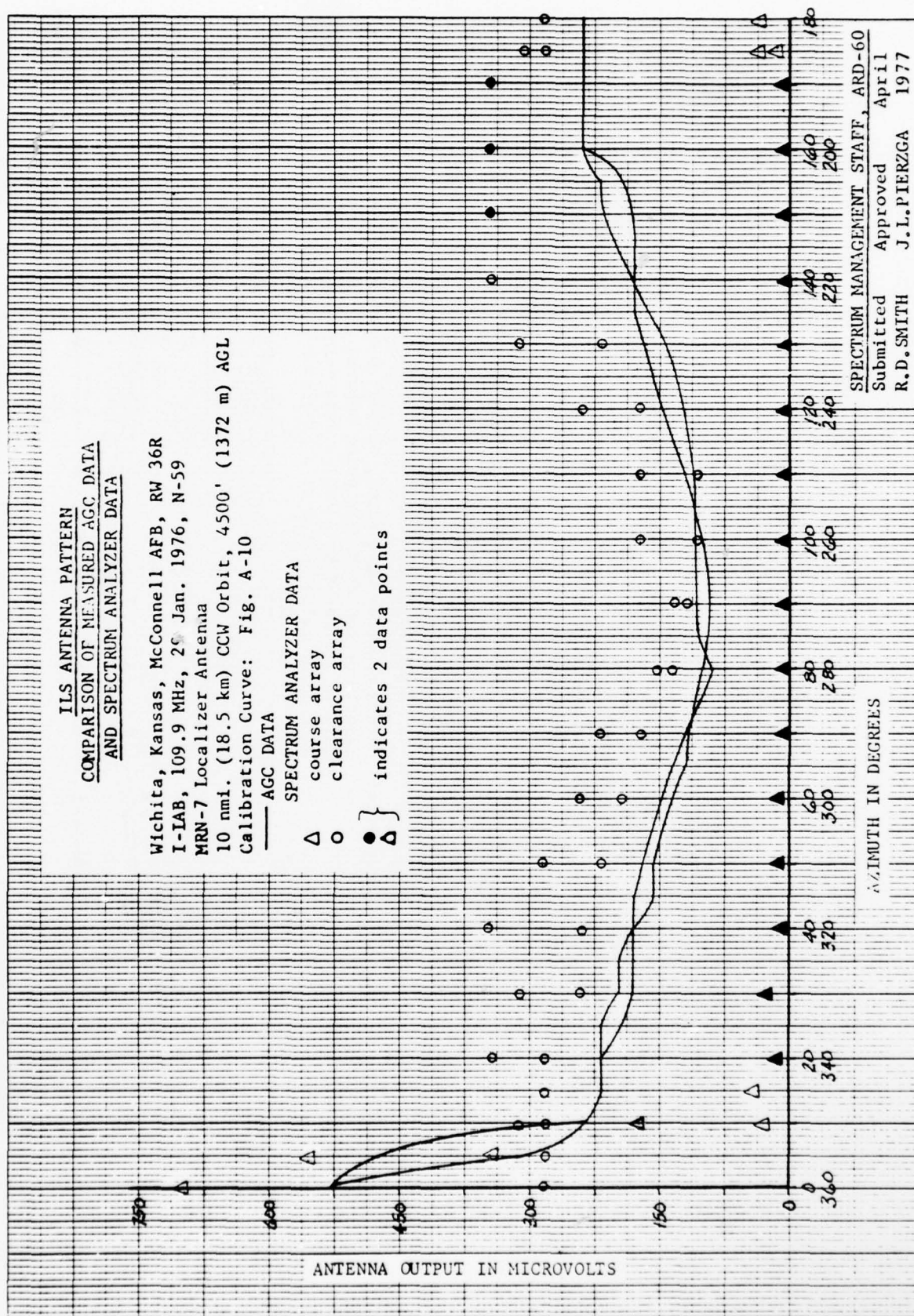


FIGURE C 7

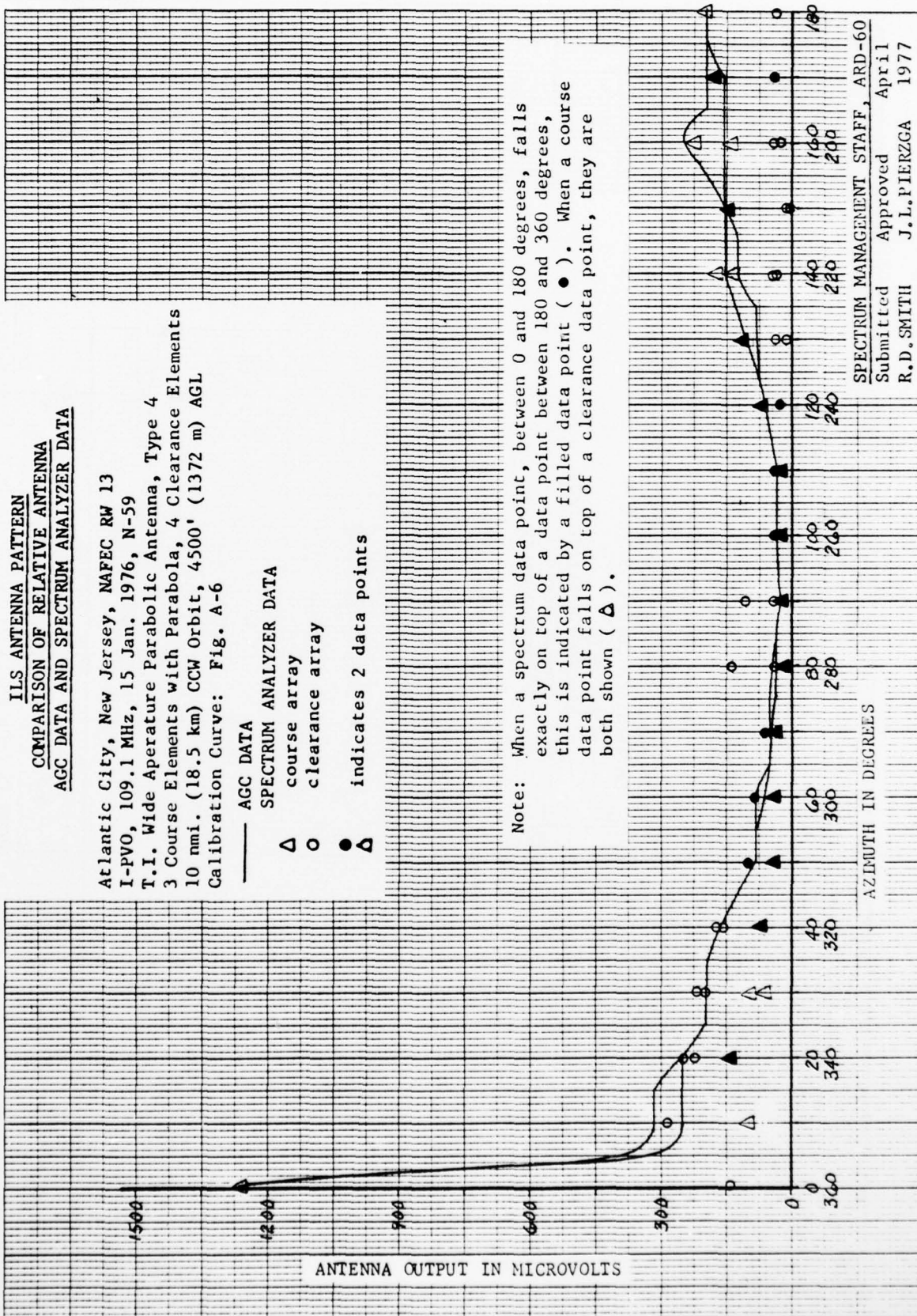


FIGURE C 8

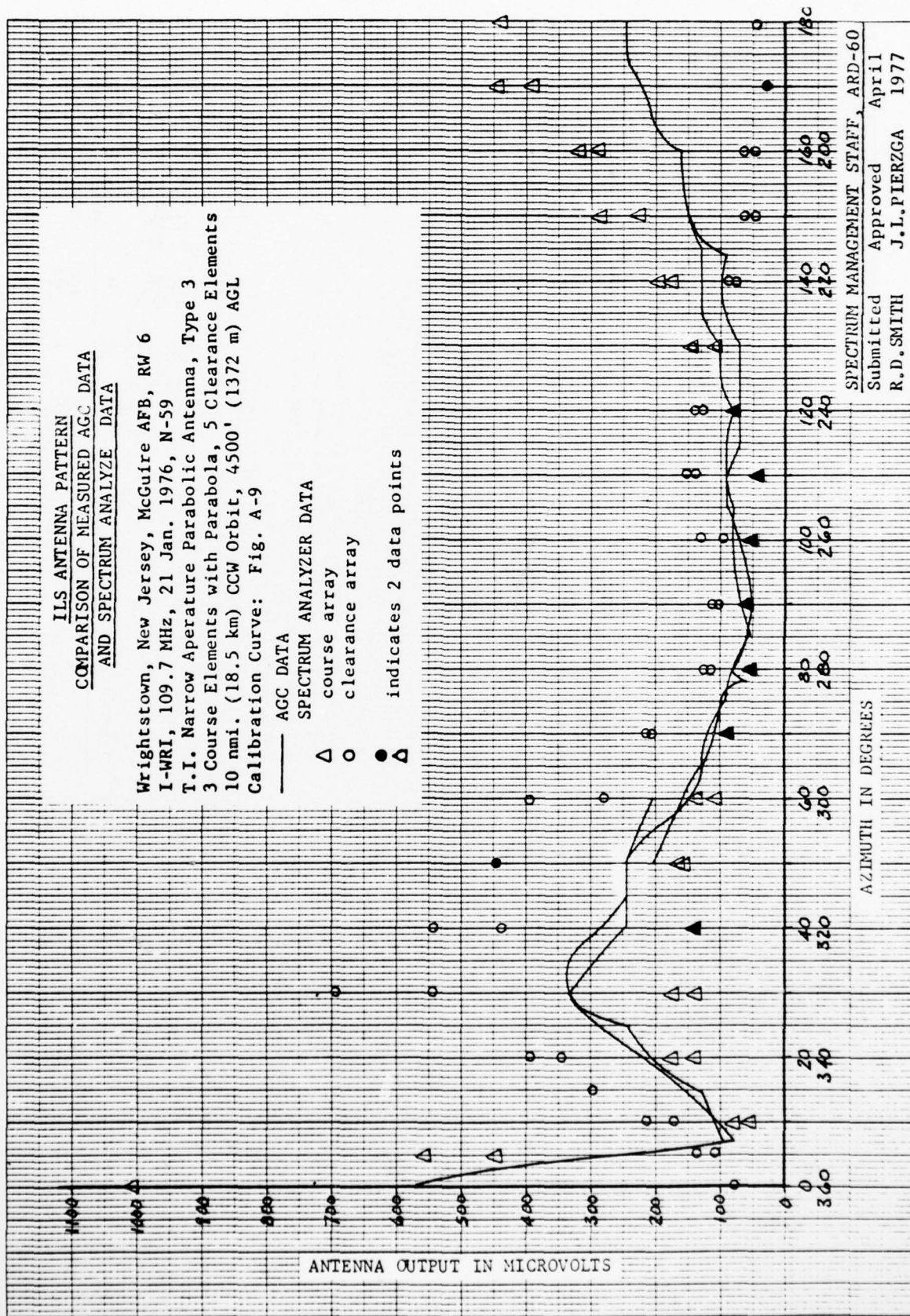


FIGURE C 9

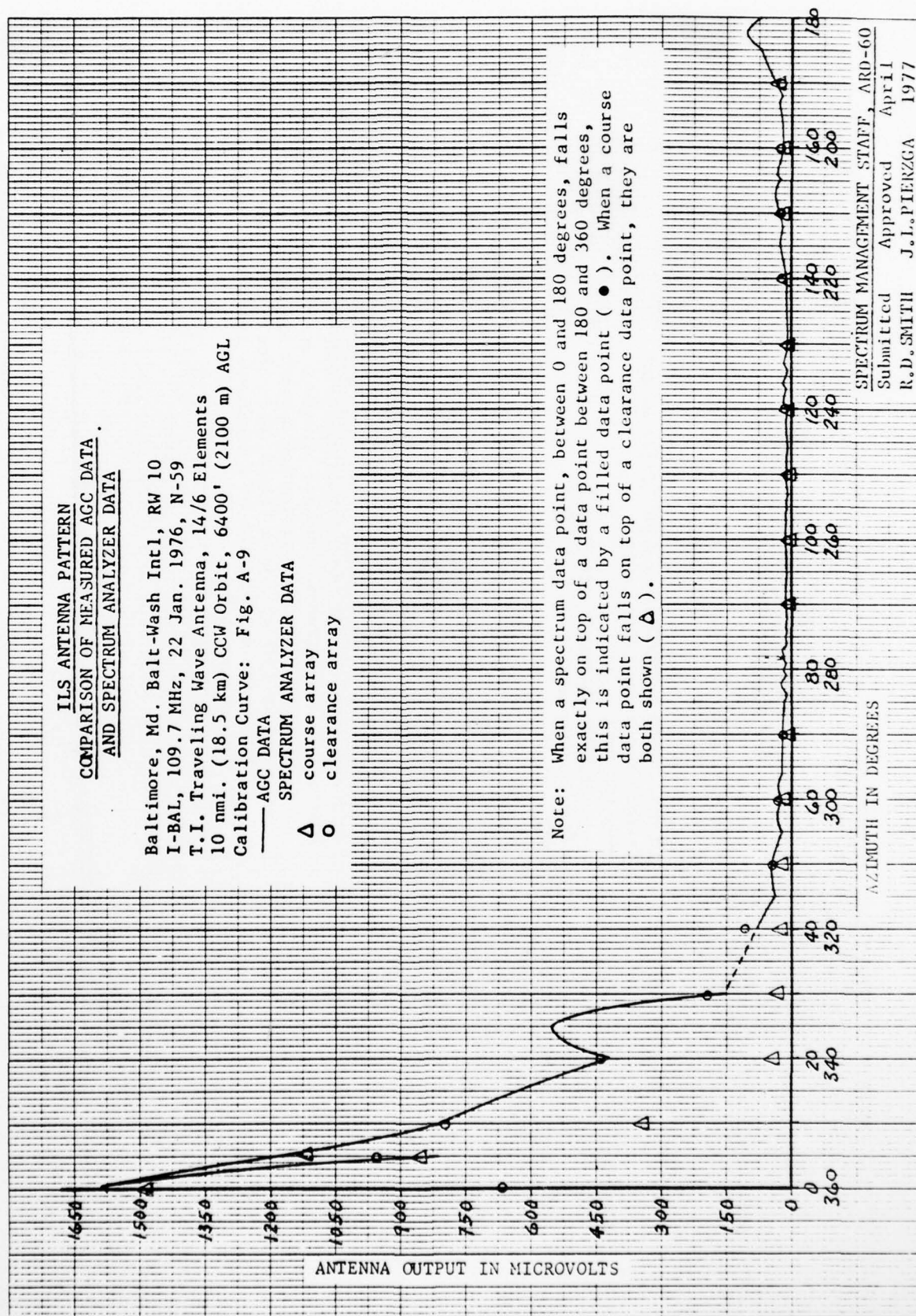


FIGURE C 10

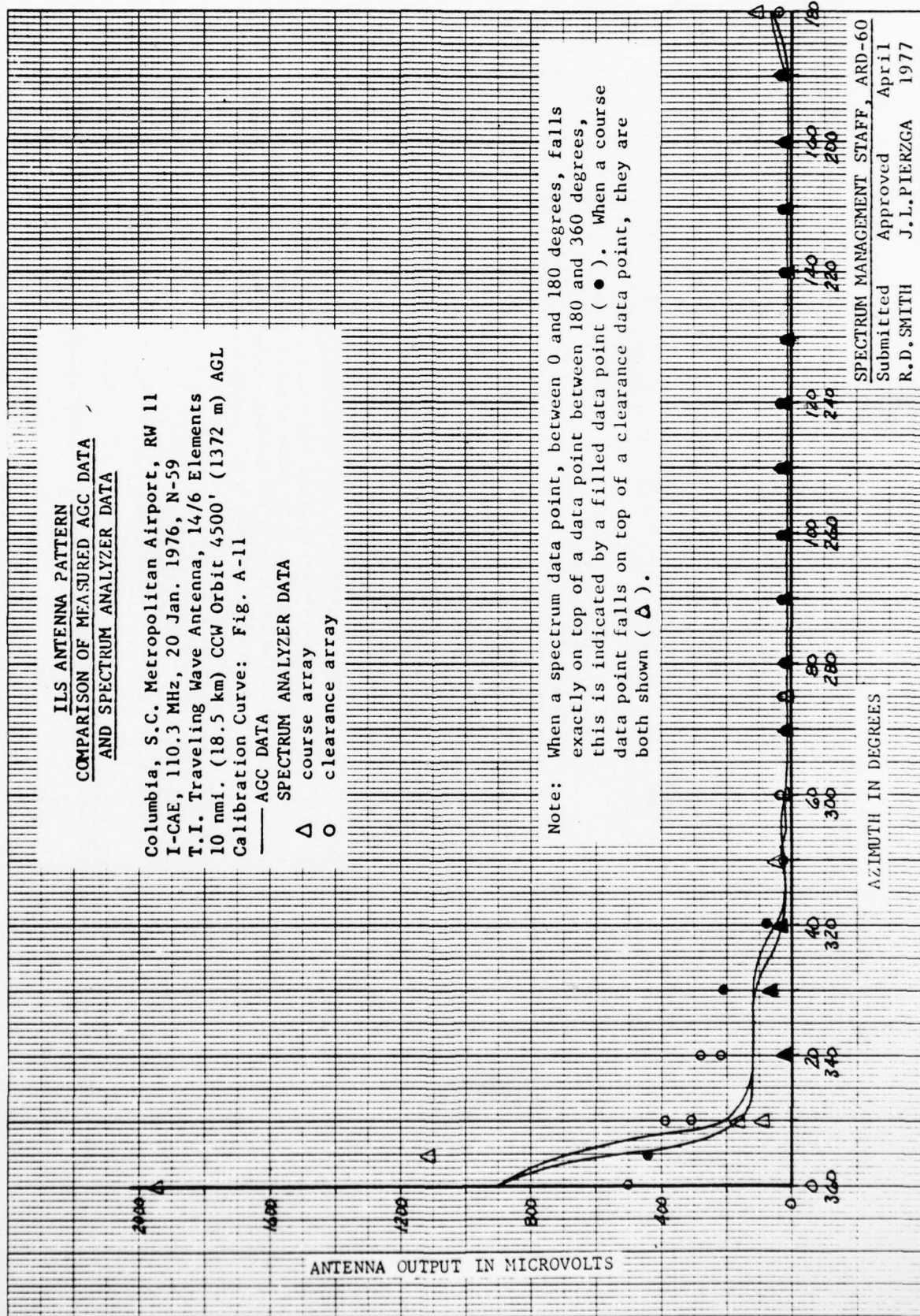


FIGURE C 11

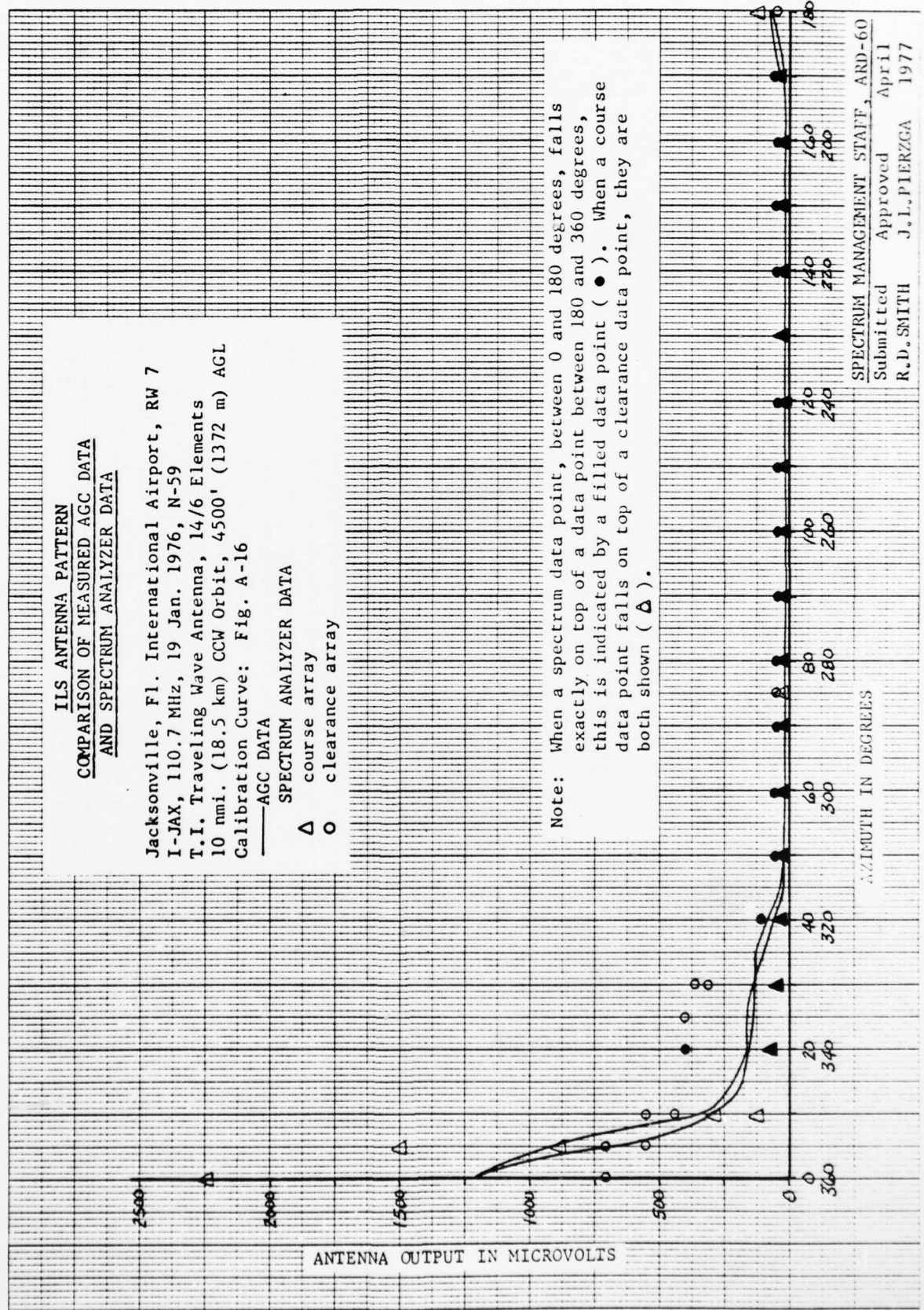


FIGURE C 12

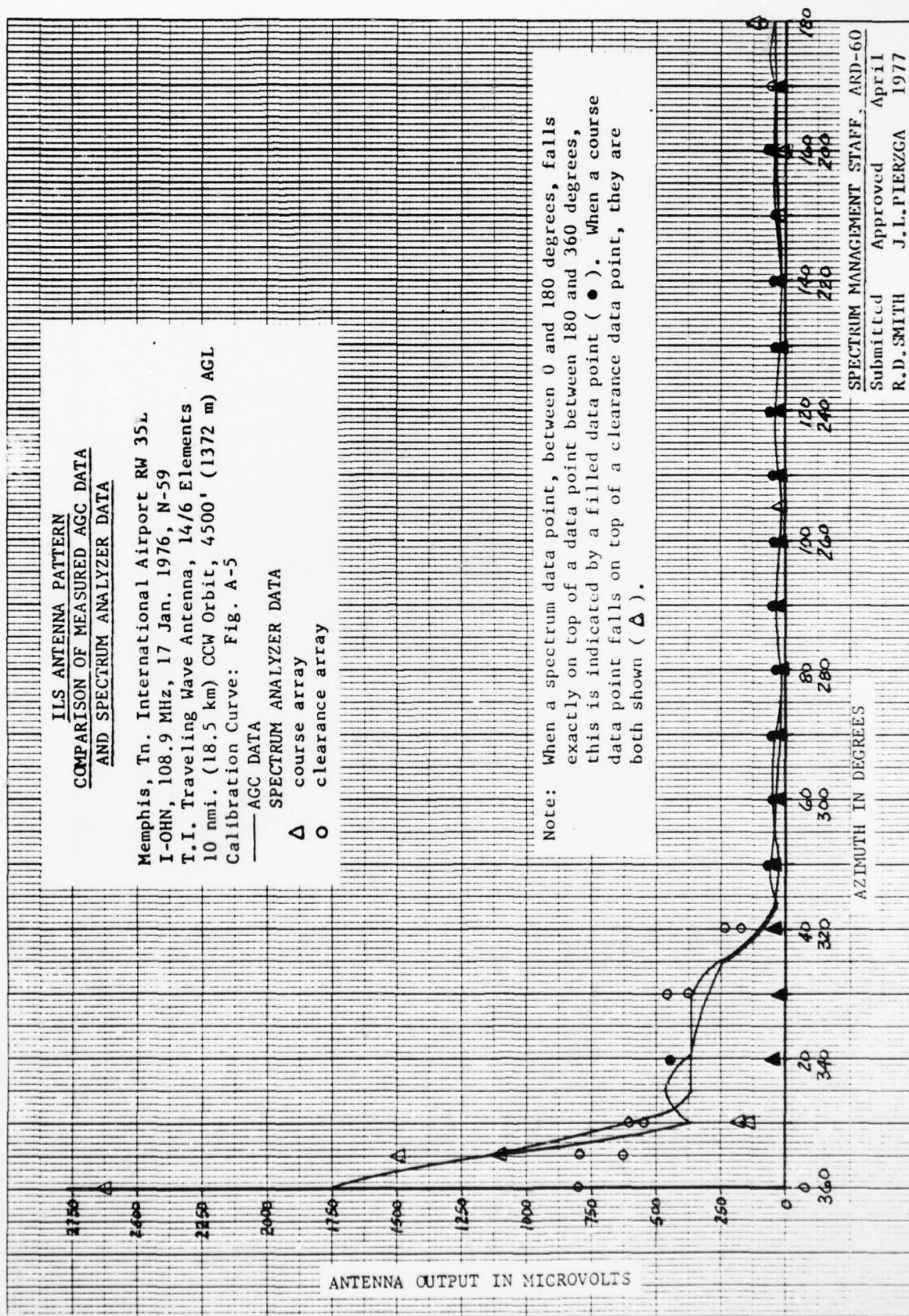


FIGURE C 13

AD-A057 935

FEDERAL AVIATION ADMINISTRATION WASHINGTON D C SYSTE--ETC F/G 17/2.1
THE SELECTION OF ILS LOCALIZER ANTENNA PATTERNS FOR USE IN THE --ETC(U)
SEP 78 R D SMITH
FAA-RD-77-130

UNCLASSIFIED

NL

2 OF 3
AD
A057935





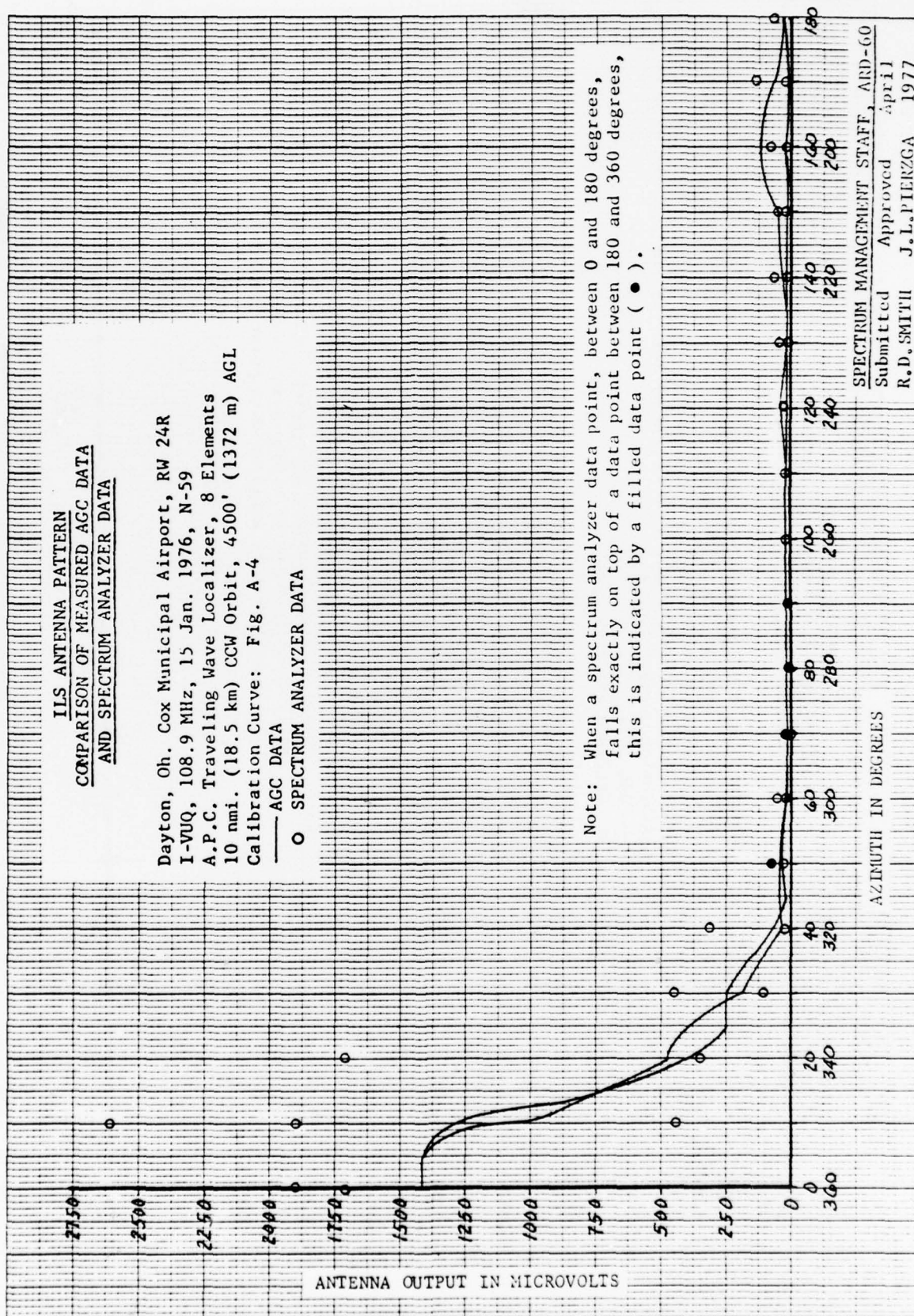


FIGURE C 14

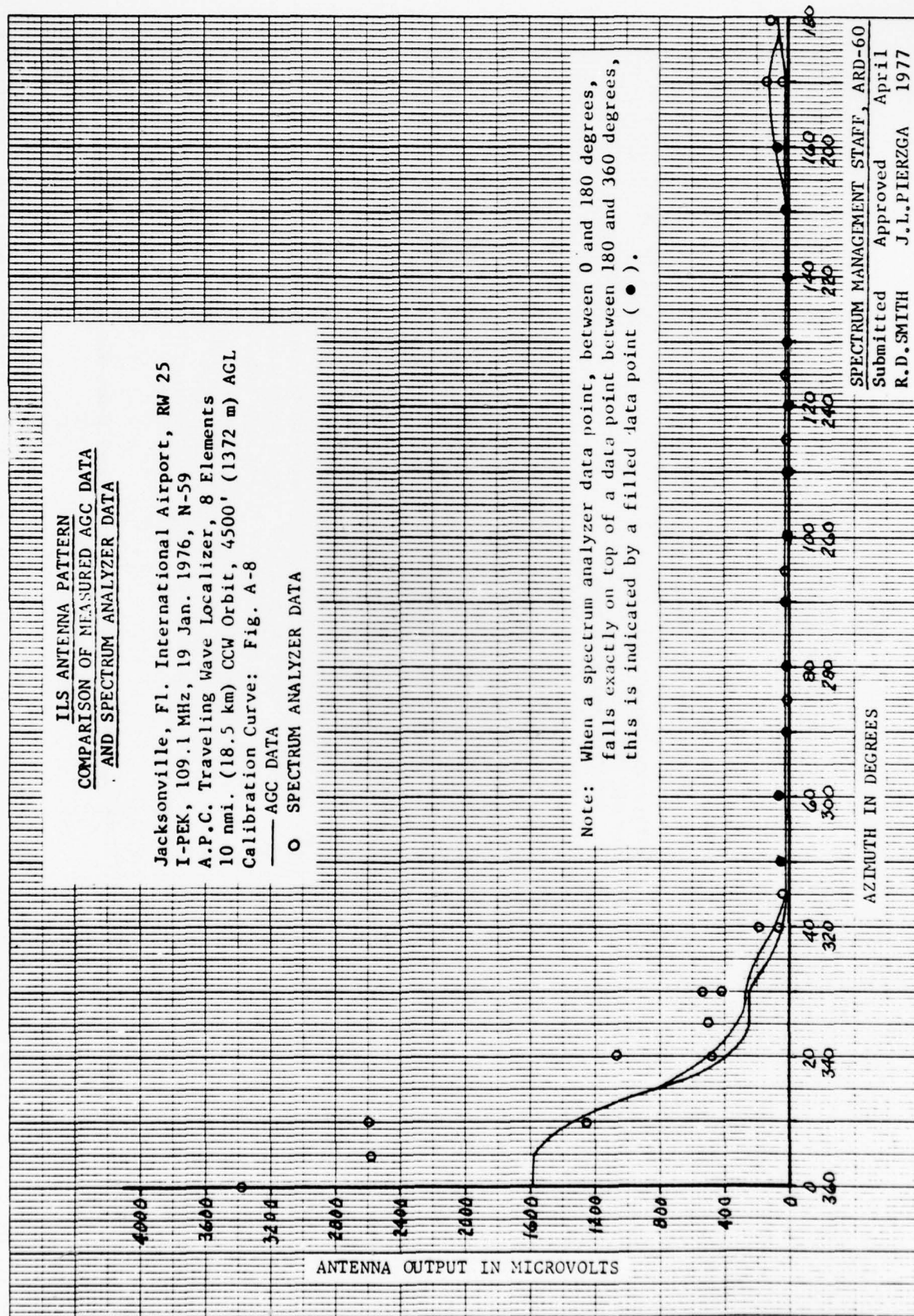


FIGURE C 15

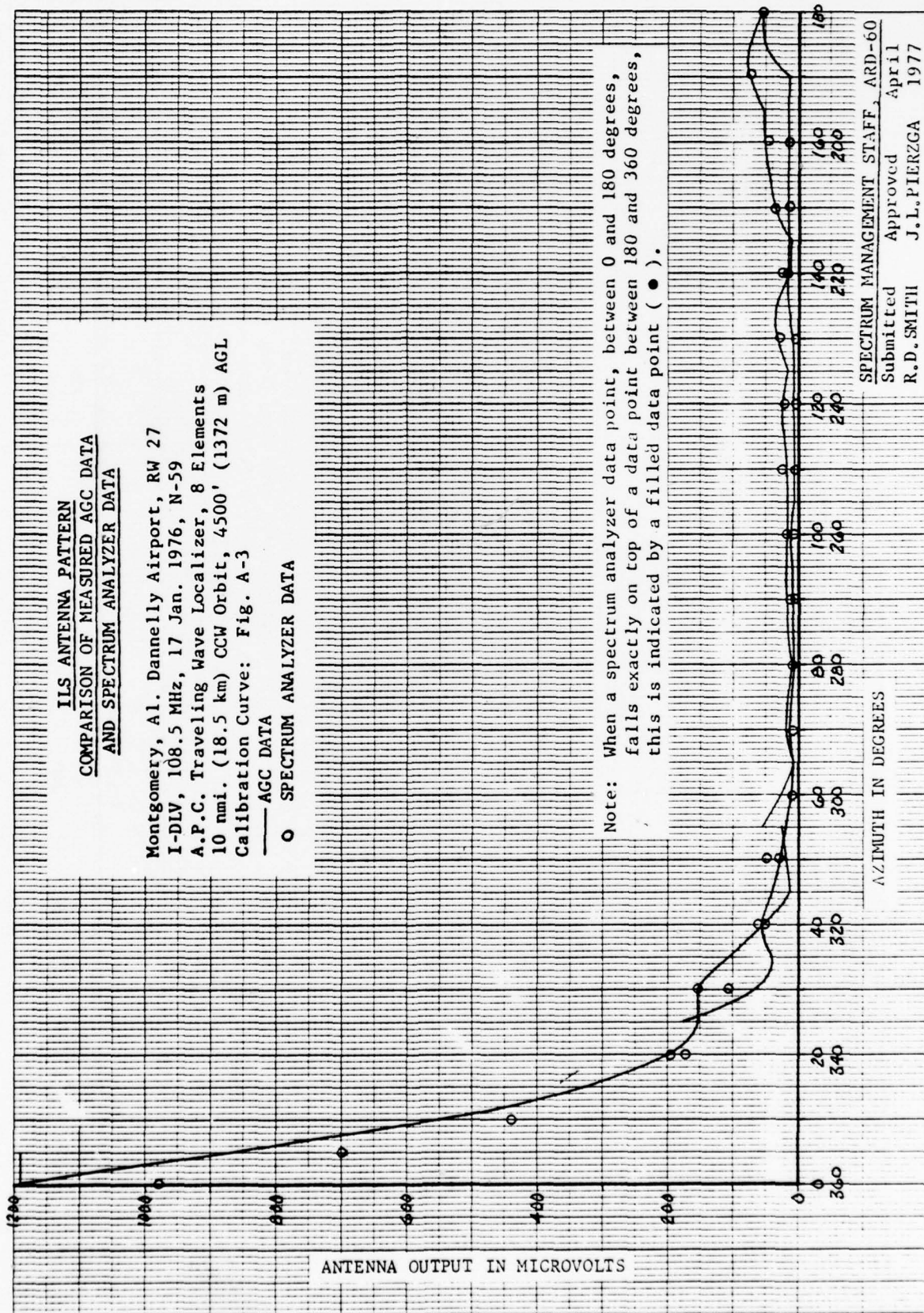


FIGURE C 16

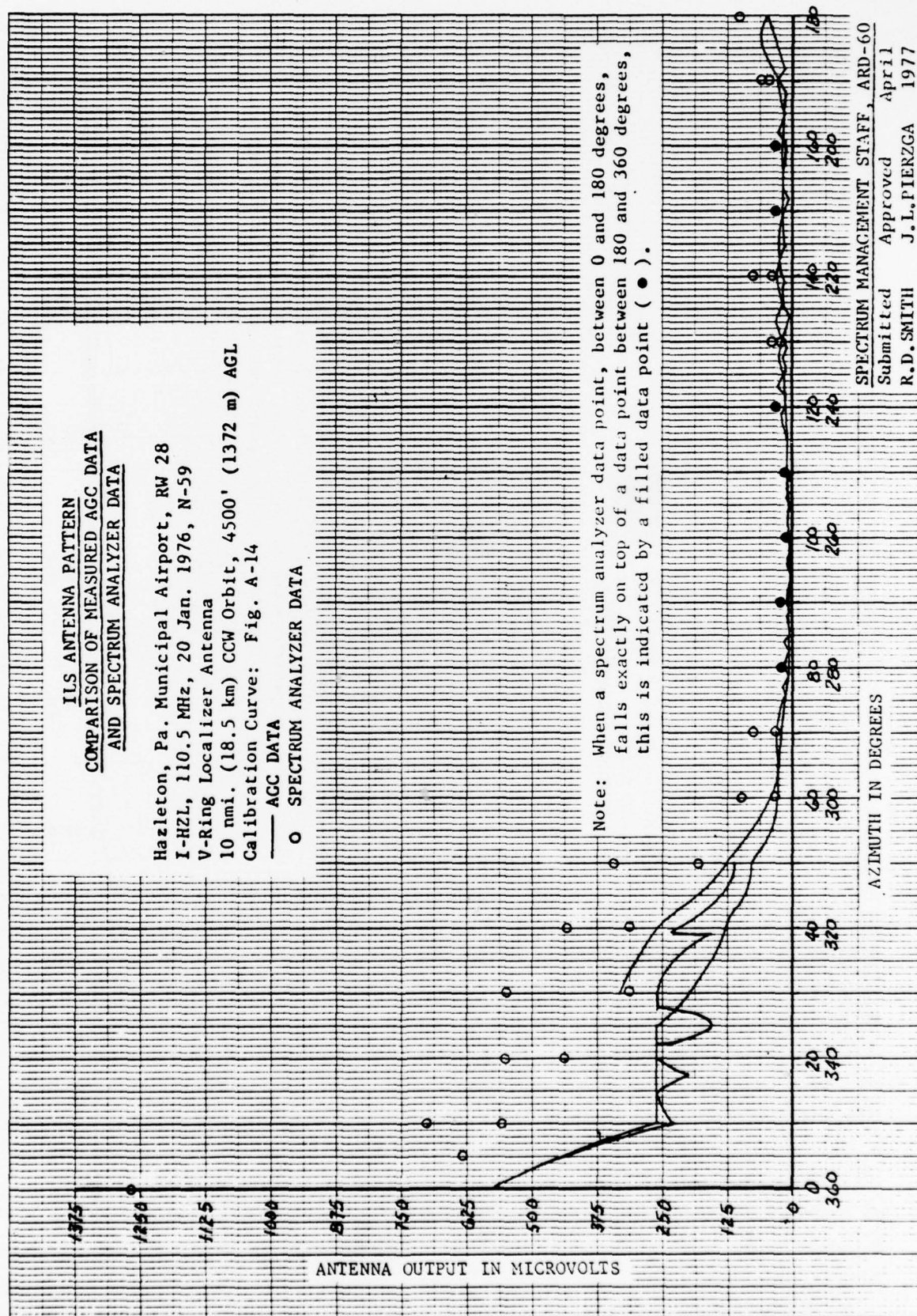


FIGURE C 17

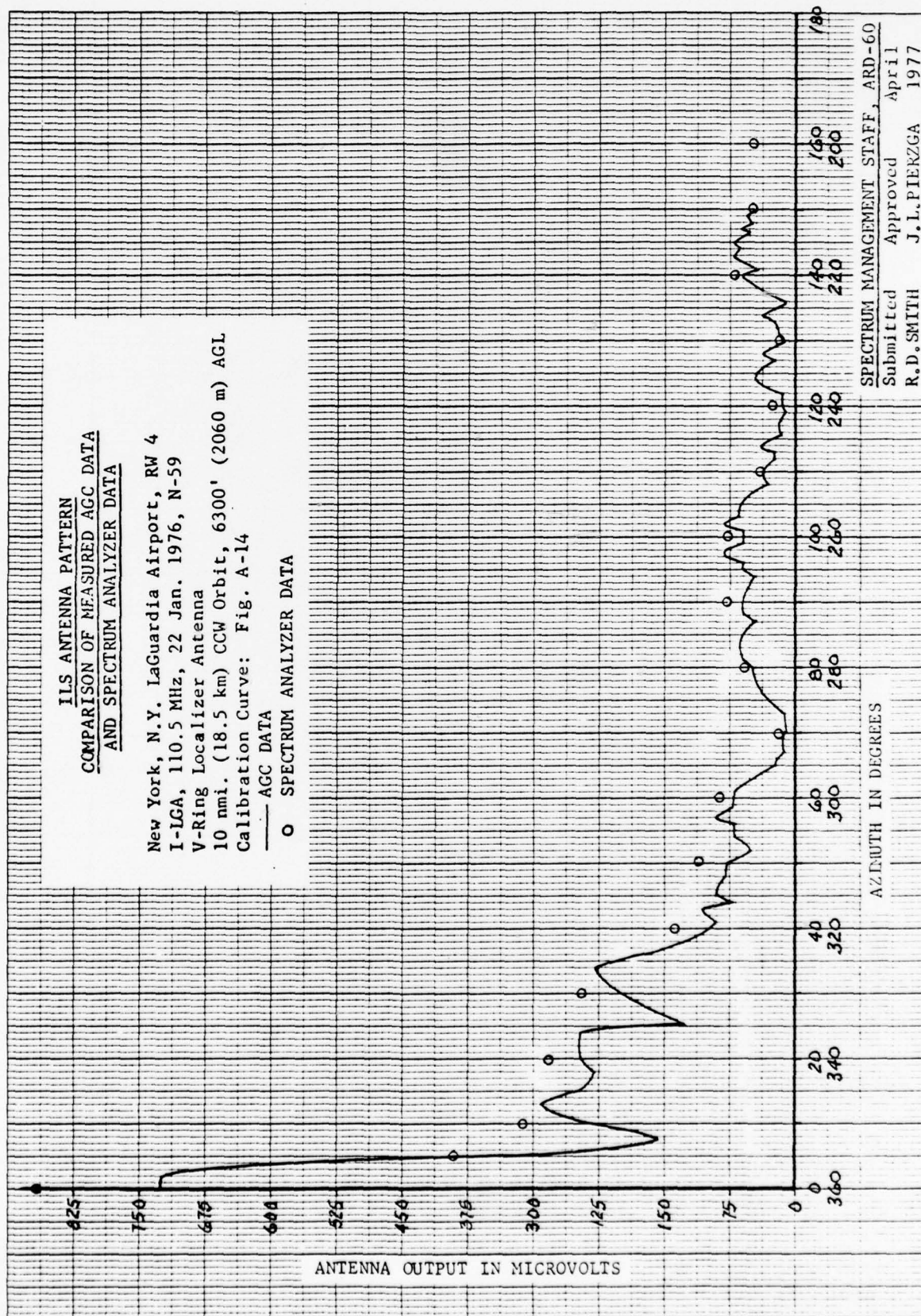


FIGURE C 18

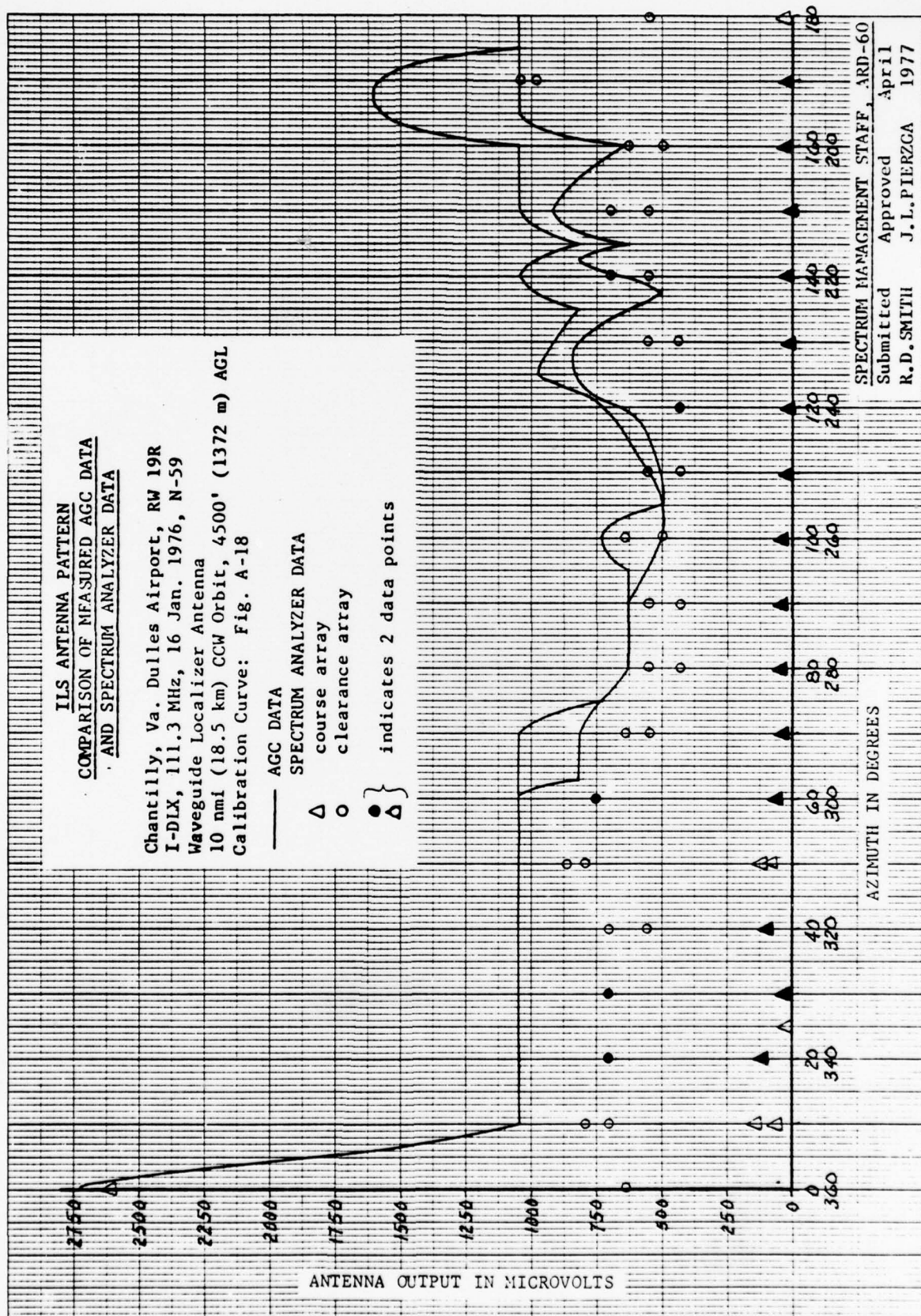


FIGURE C 19

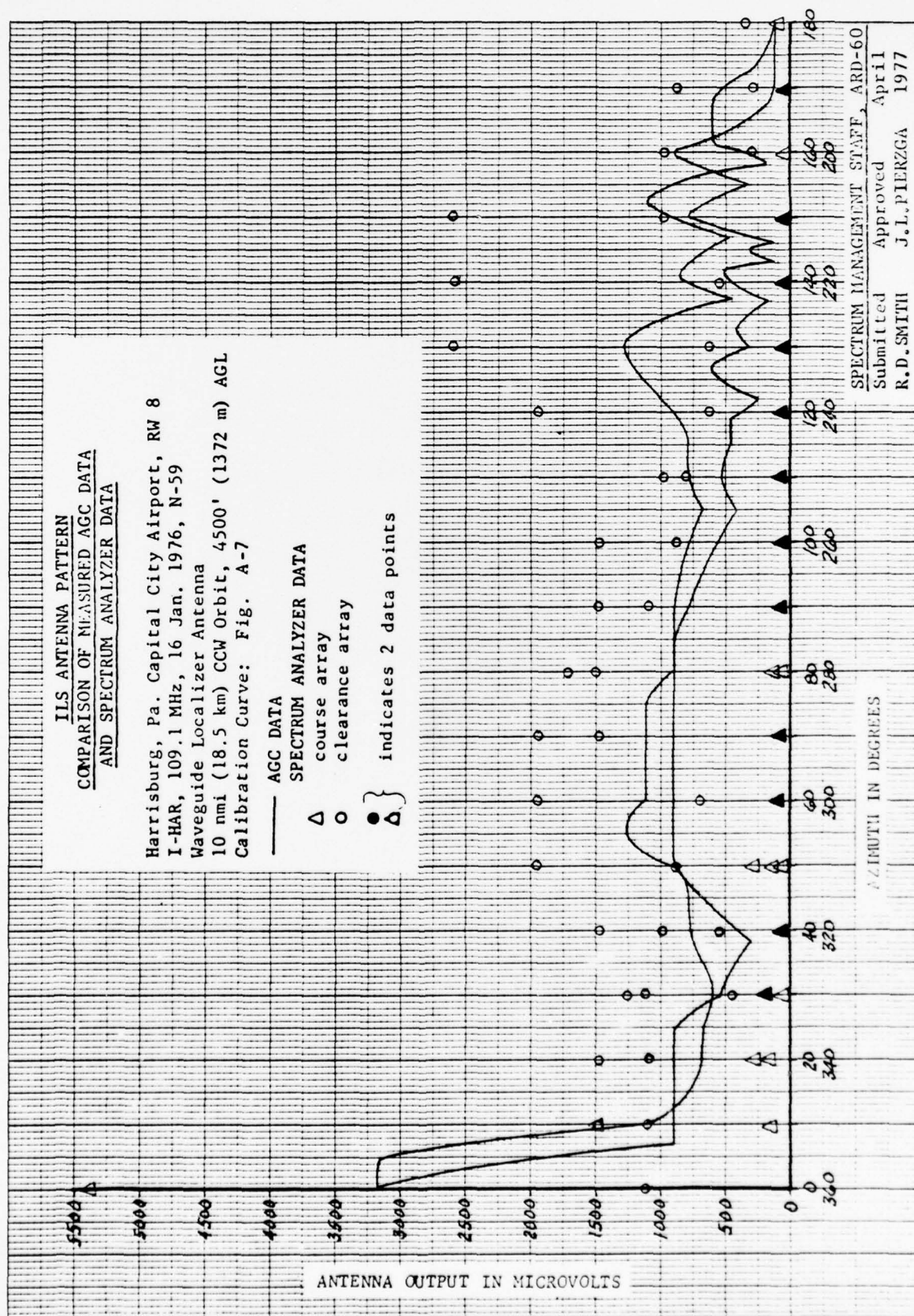


FIGURE C 20

APPENDIX D

A.I.L. TYPE 55 TWIN TEE ANTENNA

This is a single frequency, nine element array, used primarily with non-Federal systems. Each element consists of two one-half wavelength dipoles fed out of phase and spaced slightly less than one-half wavelength apart. The ends of each dipole are bent into a "tee" in order to provide clearance radiation to the sides.

A theoretical pattern for the array was obtained from the manufacturer's instruction handbook (Figure D1). It only shows ± 90 degrees, but according to the handbook, the front to back ratio is unity. With that assumption, theoretical data compares well with the data measured by FINFO at several facilities (Figure D2). Data taken at Latrobe, Pennsylvania, in October 1969 (Figures D3 through D7) does not agree as well since the front to back ratio is approximately 5 dB.

Since this is a non-Federal system, no FAA specifications on antenna patterns were found to be applicable.

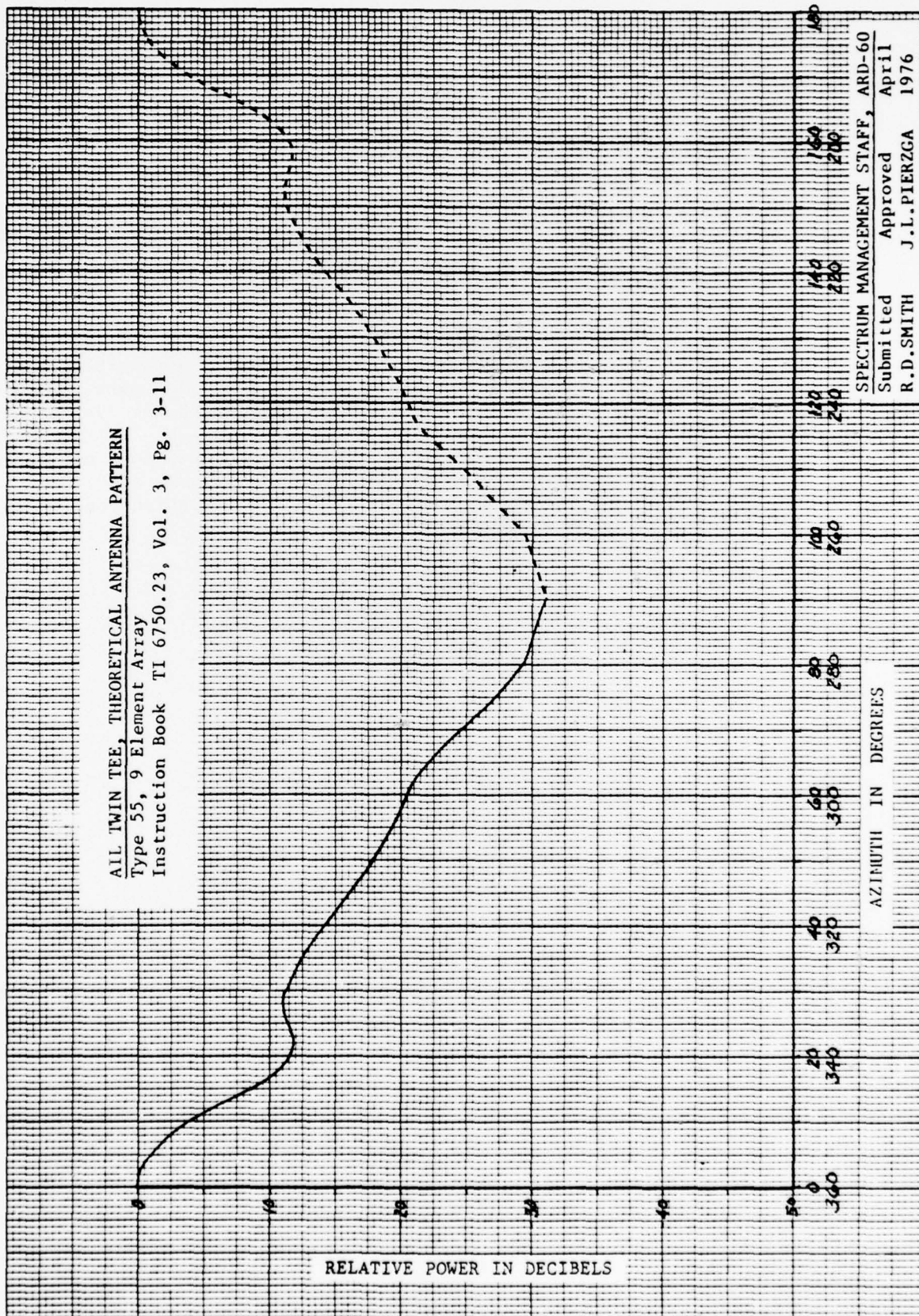


FIGURE D 1

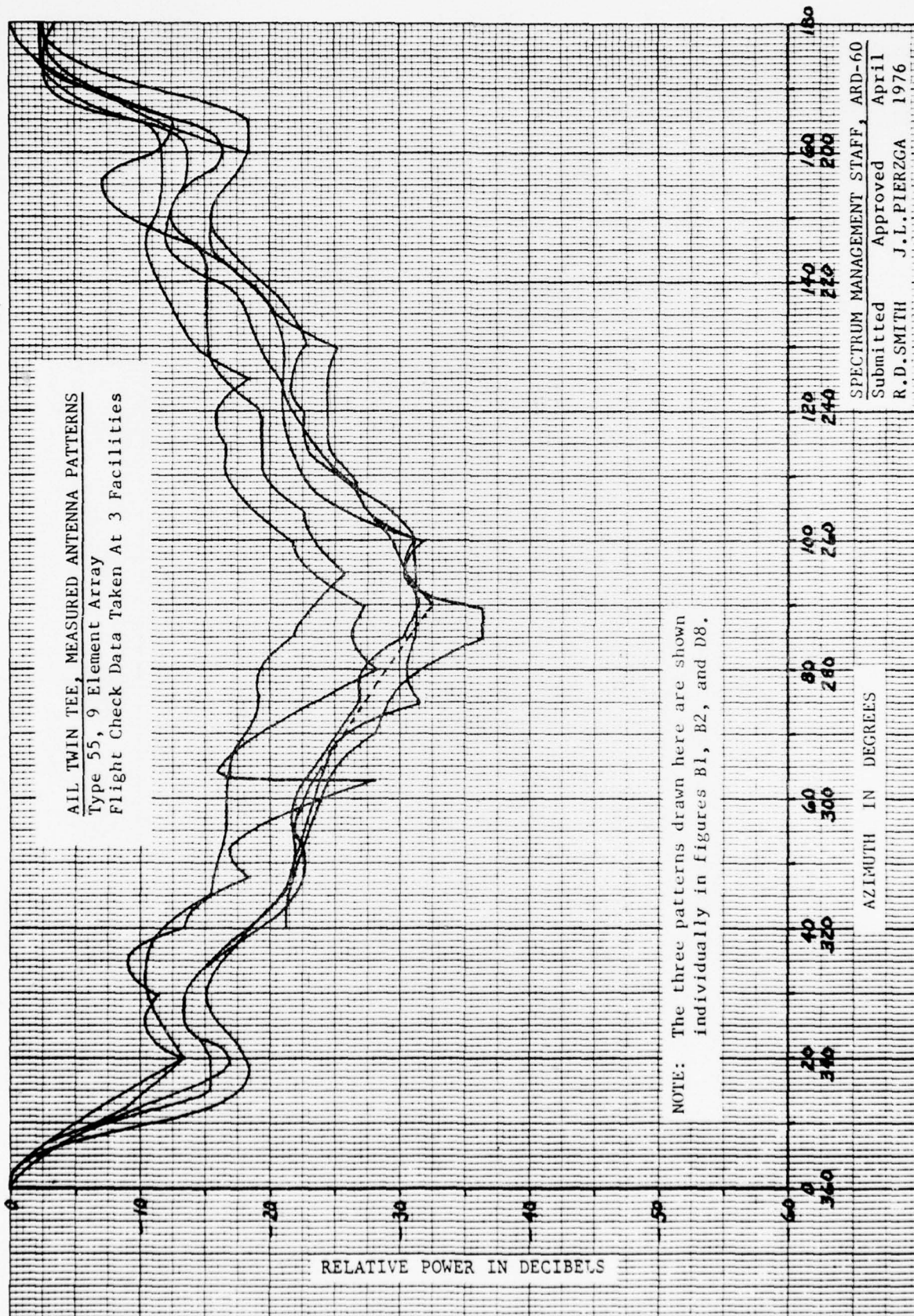


FIGURE D 2

MEASURED A.I.L. TWIN TEE ANTENNA PATTERNS

Type 55, 9 Element Localizer Array
 Flight Data at 4 Altitudes, 25 nmi. (46.3 km) Orbits
 Latrobe, Pa. Latrobe Field, RW 23
 I-LBE, 110.9 MHz, N-102, 29 Oct. 1969
 Antenna Height: 9.33' (3.06 m) Above Ground
 FAA-RD-75-165, Vol. II, pg. H-1 thru H-4

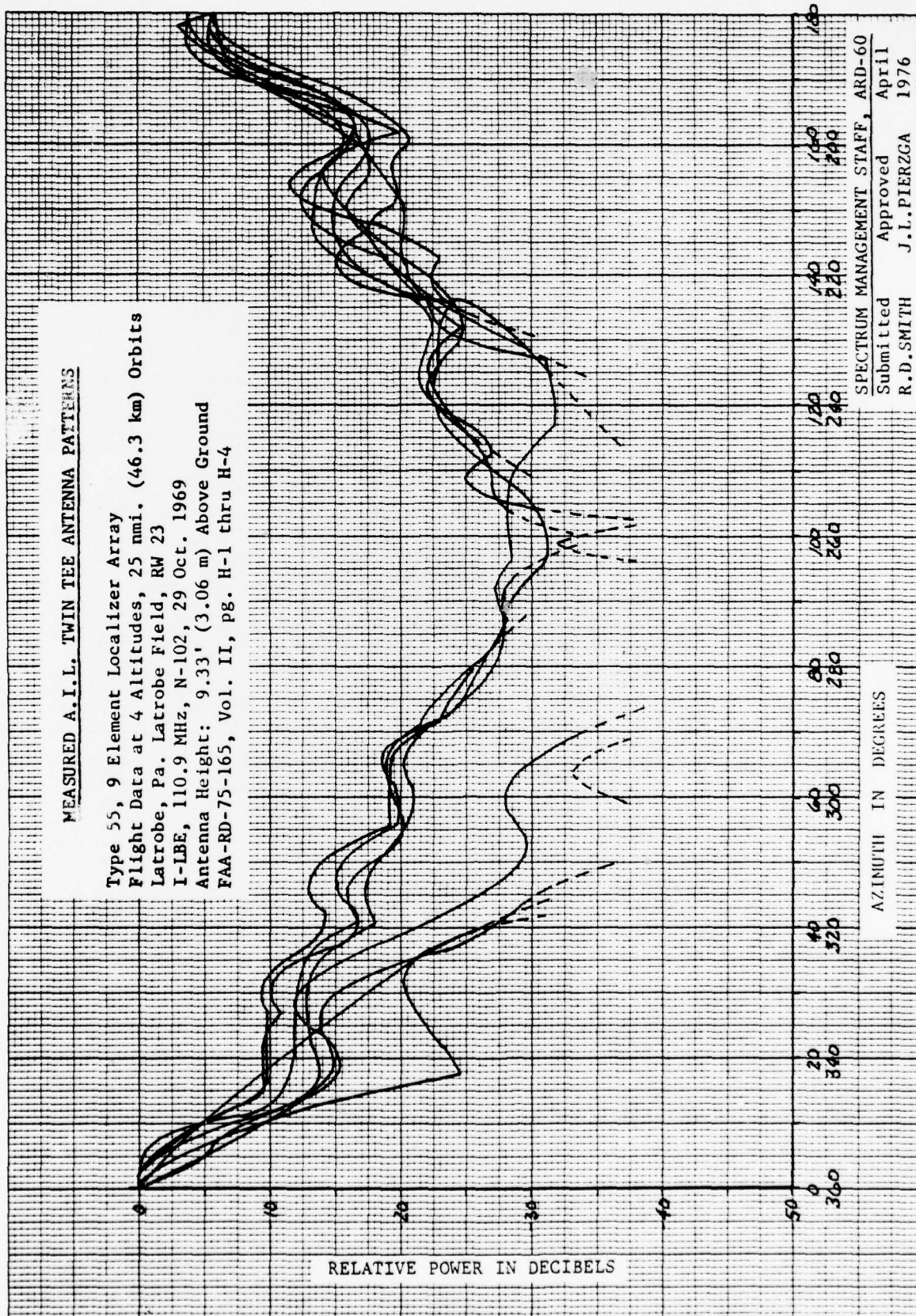


FIGURE D 3

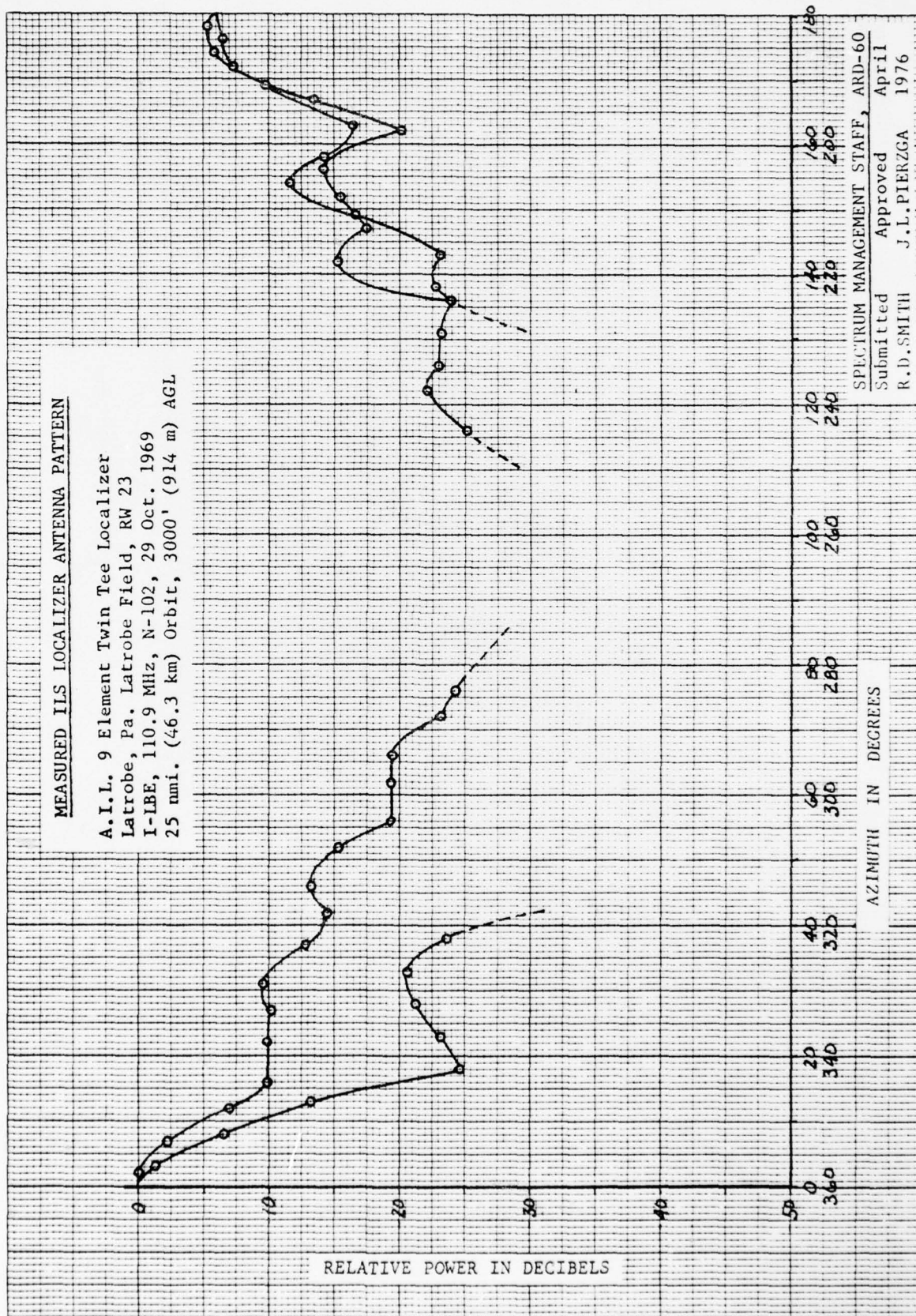


FIGURE D 4

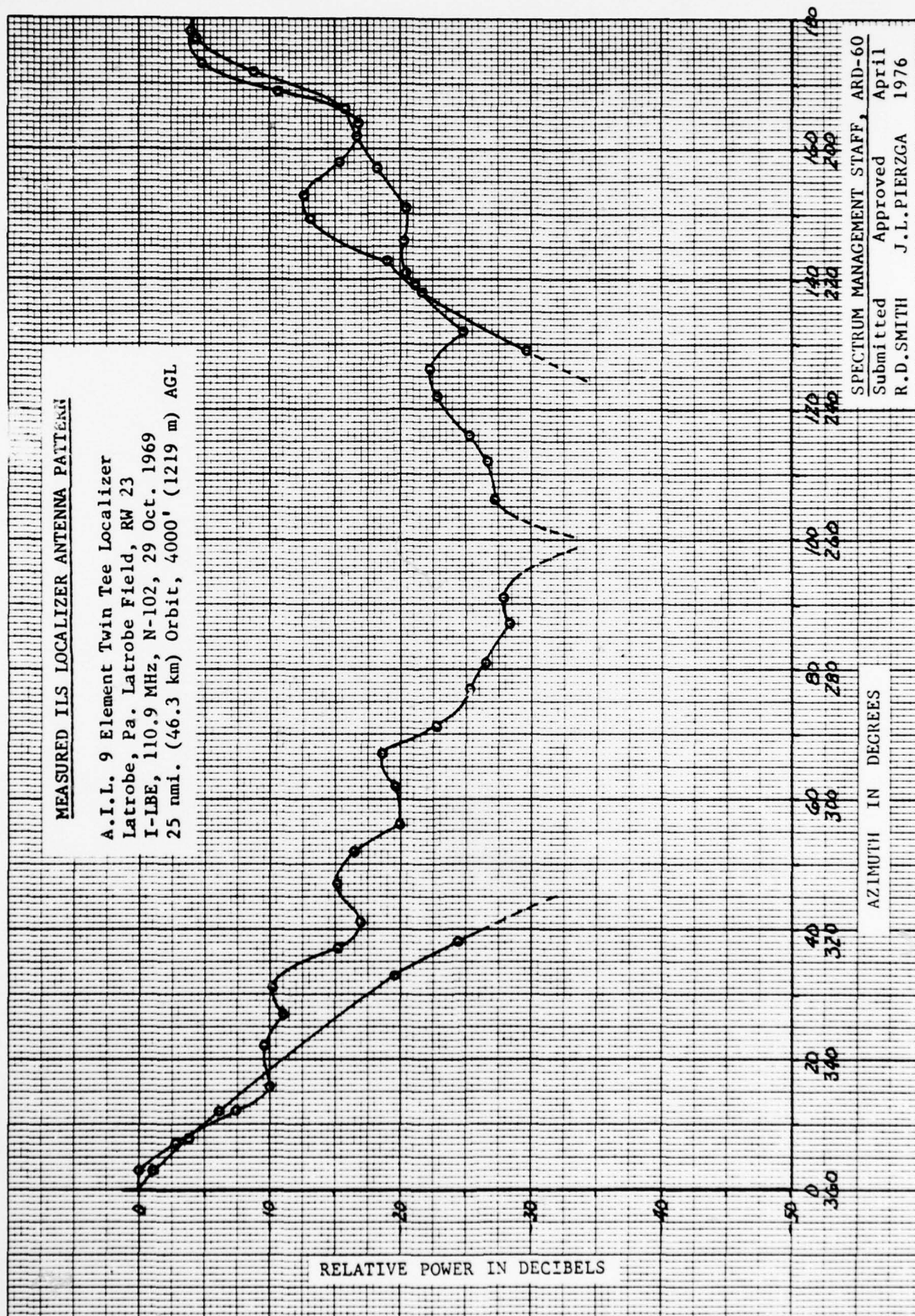


FIGURE D 5

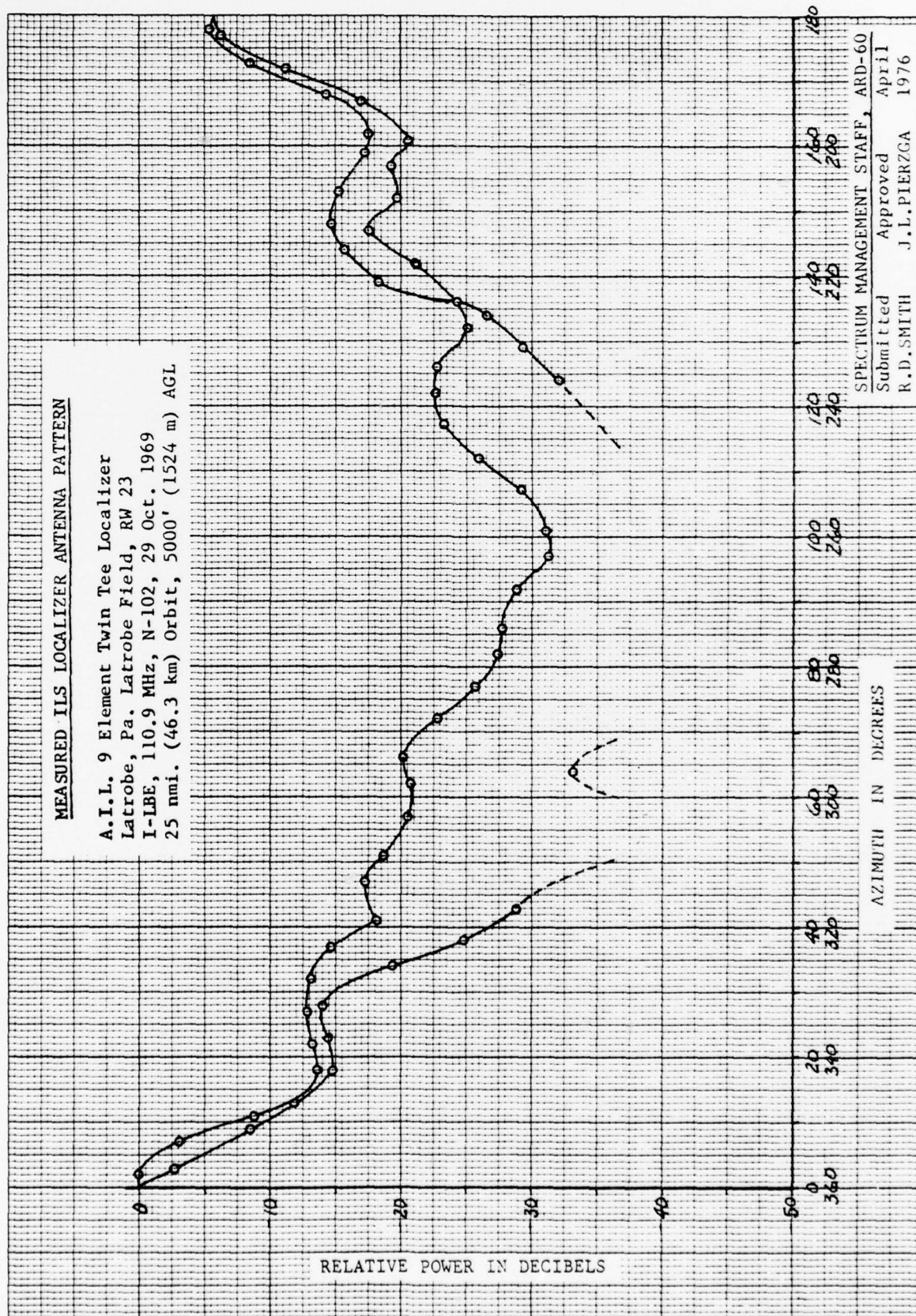


FIGURE D 6

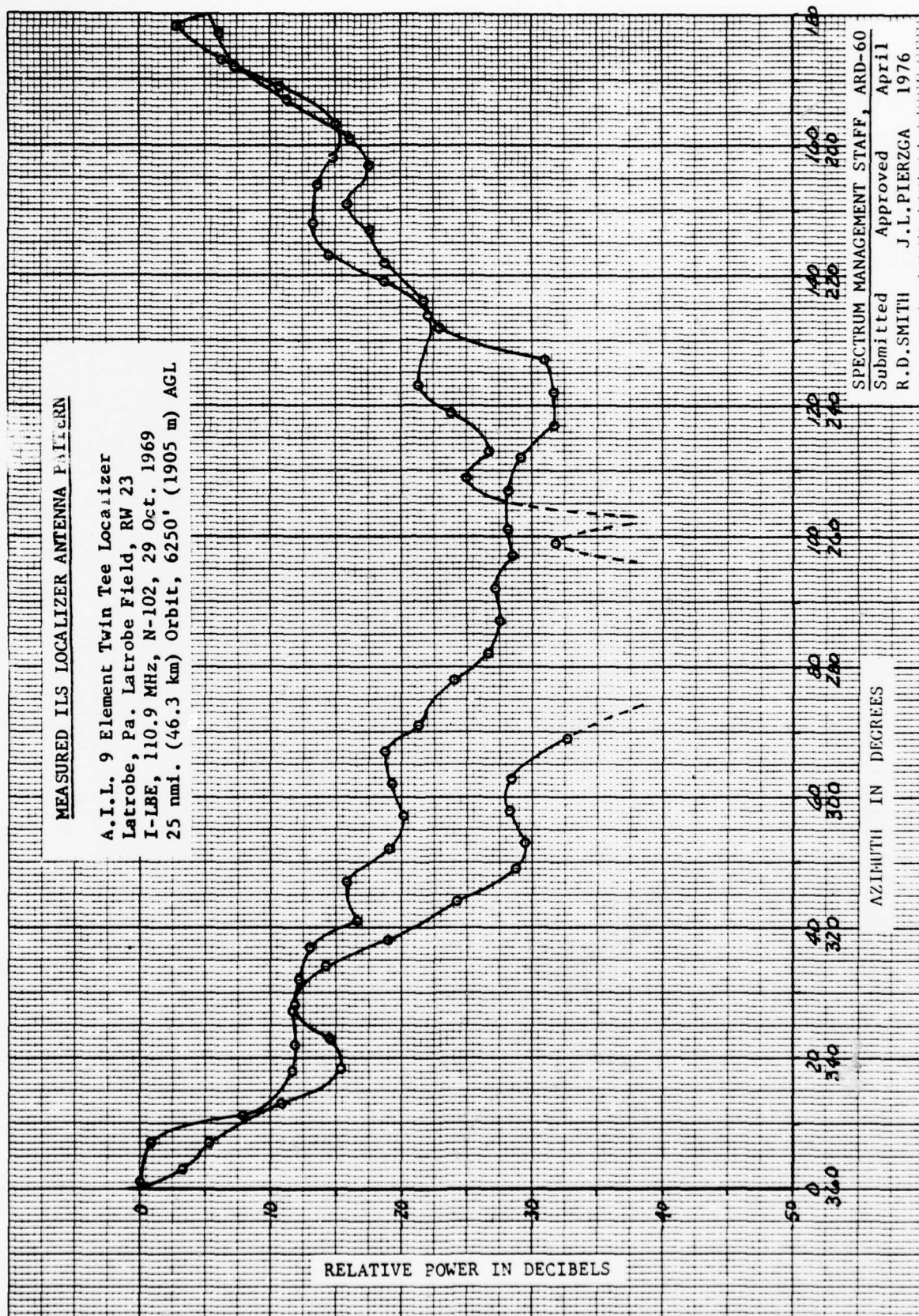


FIGURE D 7

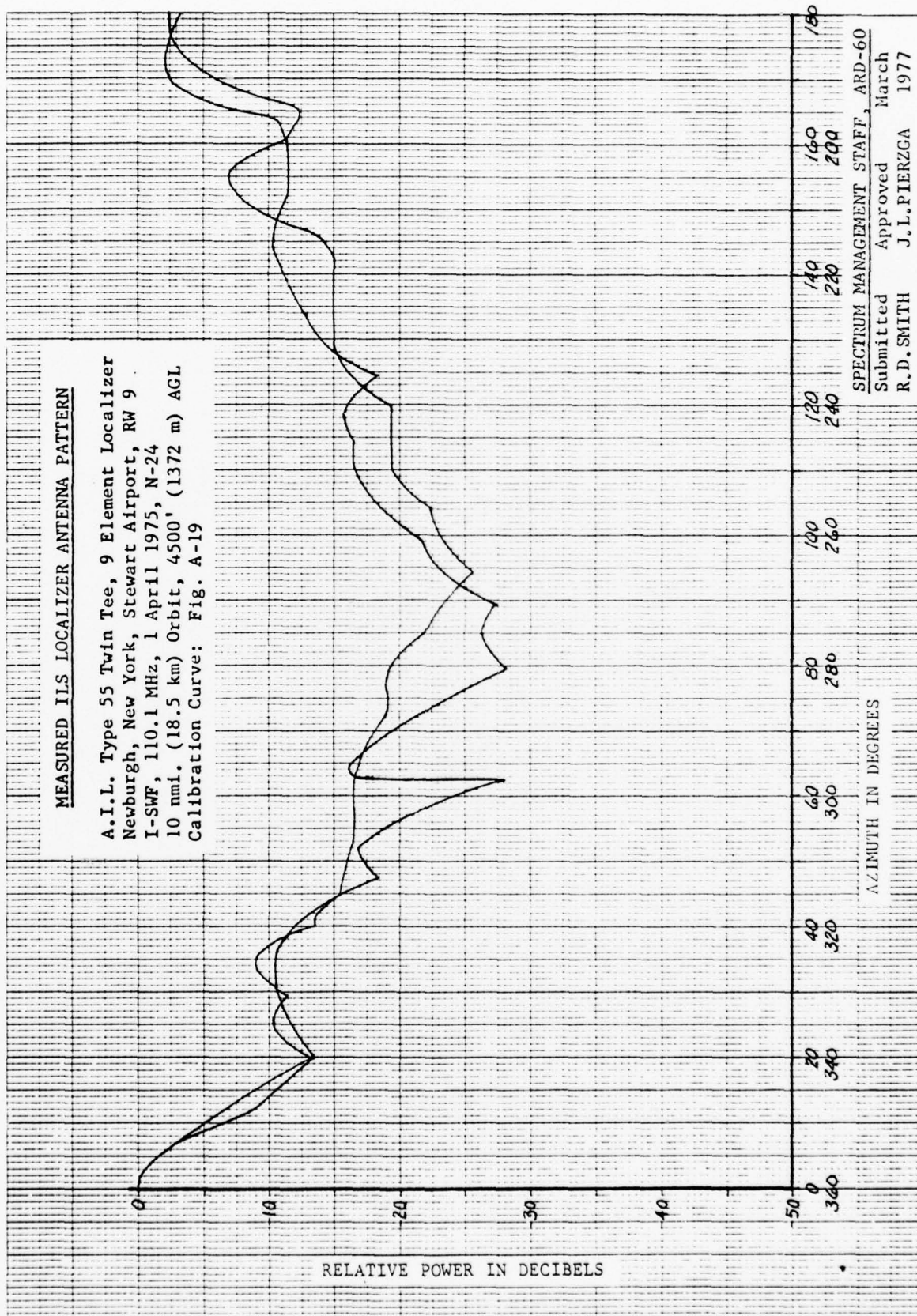


FIGURE D 8

APPENDIX E

EIGHT LOOP ANTENNA

Years ago, this was considered the standard ILS antenna. It consists of eight Alford loop antennas. A glance at the theoretical pattern shows that the radiation pattern has very little directivity. This was quite useful when it was considered necessary to maintain a clearance signal in all directions. Today's highly directional arrays have come into favor because they result in less multipath, thereby insuring a smoother course. The two frequency, capture effect antennas, are particularly effective in this respect.

Measured data taken at Calverton, N.Y. (Figure E2) agrees well with the theoretical pattern. Measured data taken at Dallas (Figures E3 through E9) agrees less well. This particular antenna had a small screen behind it. It is assumed that shielding by this screen resulted in the front to back ratio apparent in the data. Taking this into consideration, the measured data compares fairly well with the theoretical curve.

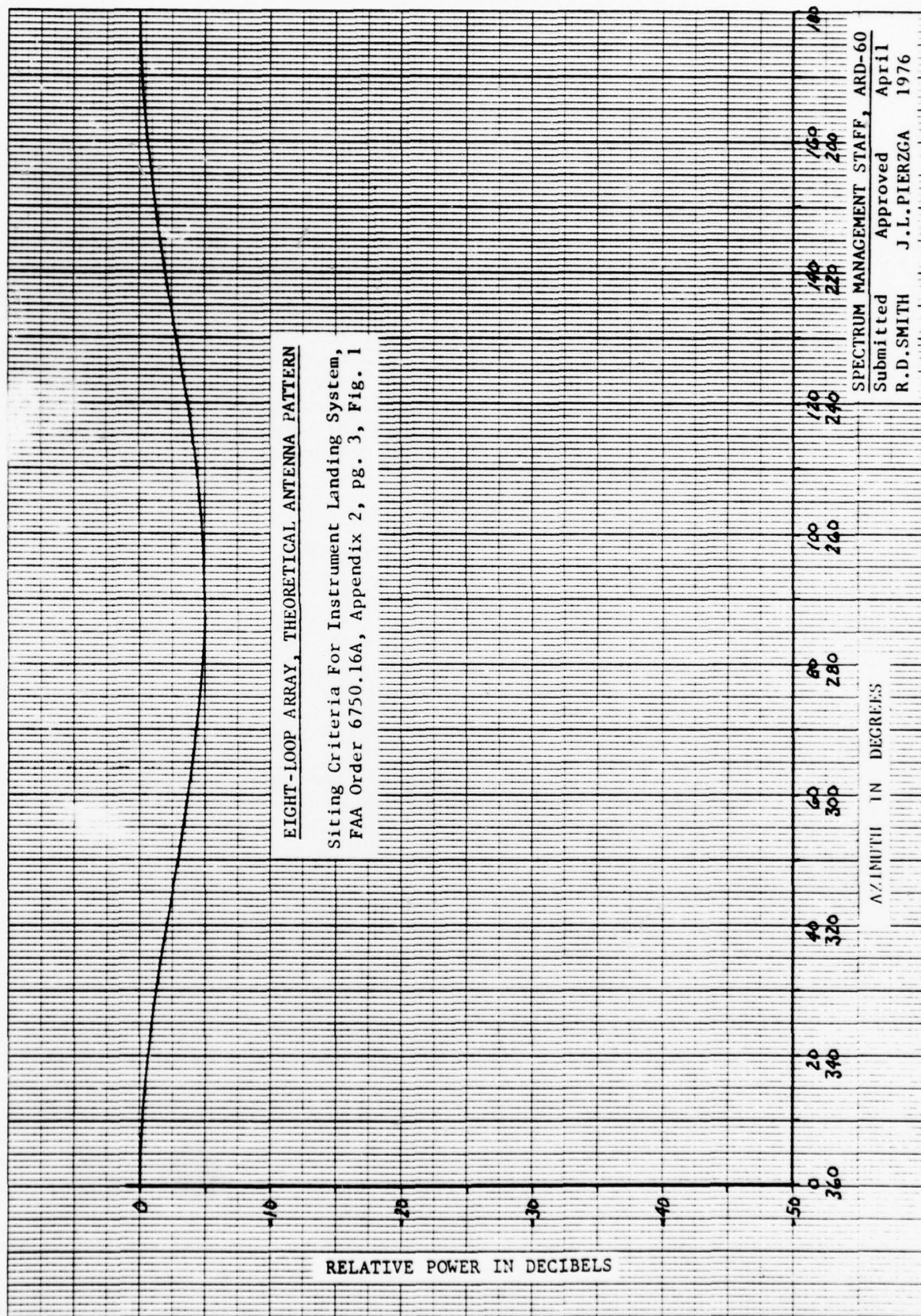


FIGURE E 1

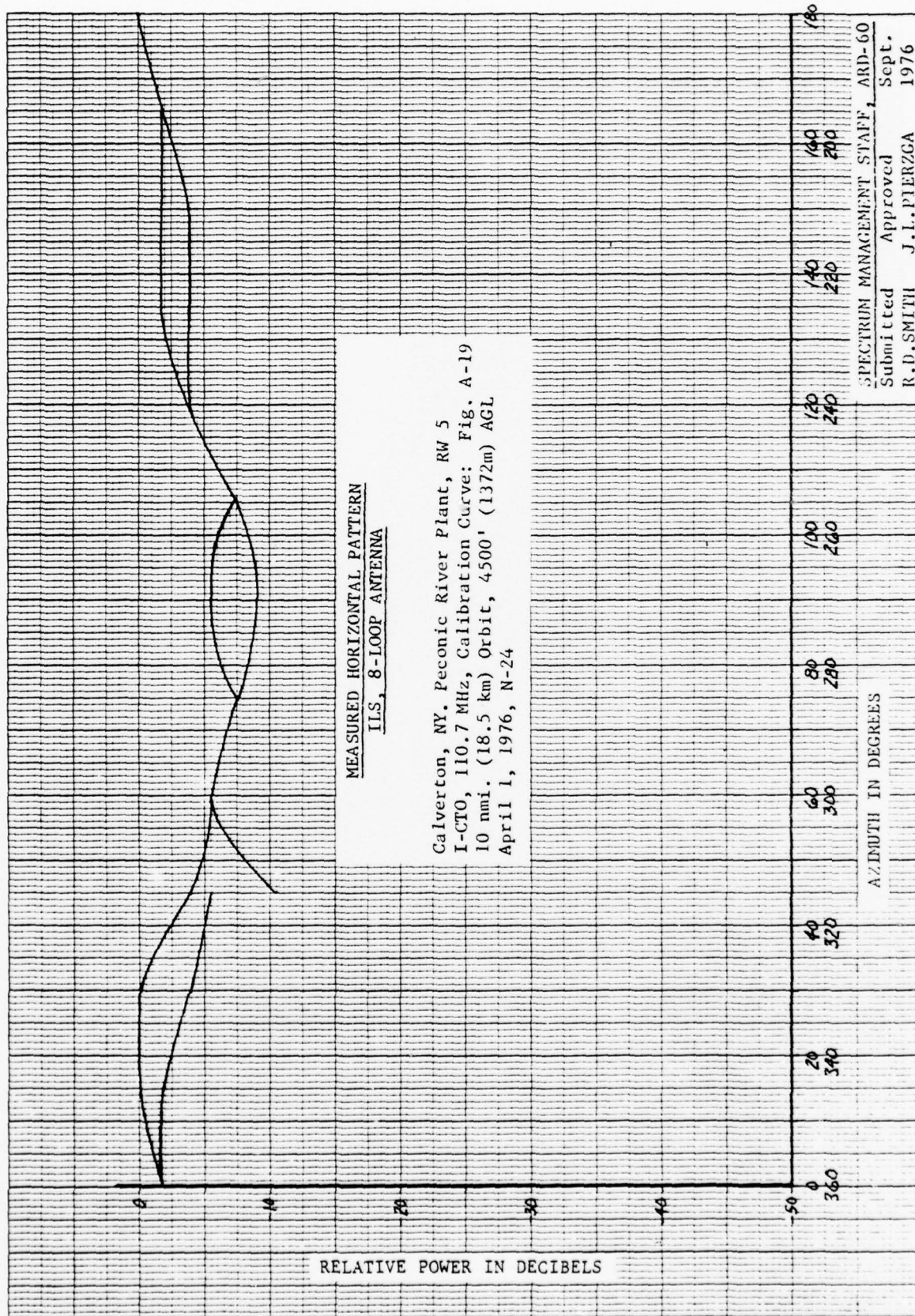


FIGURE E 2

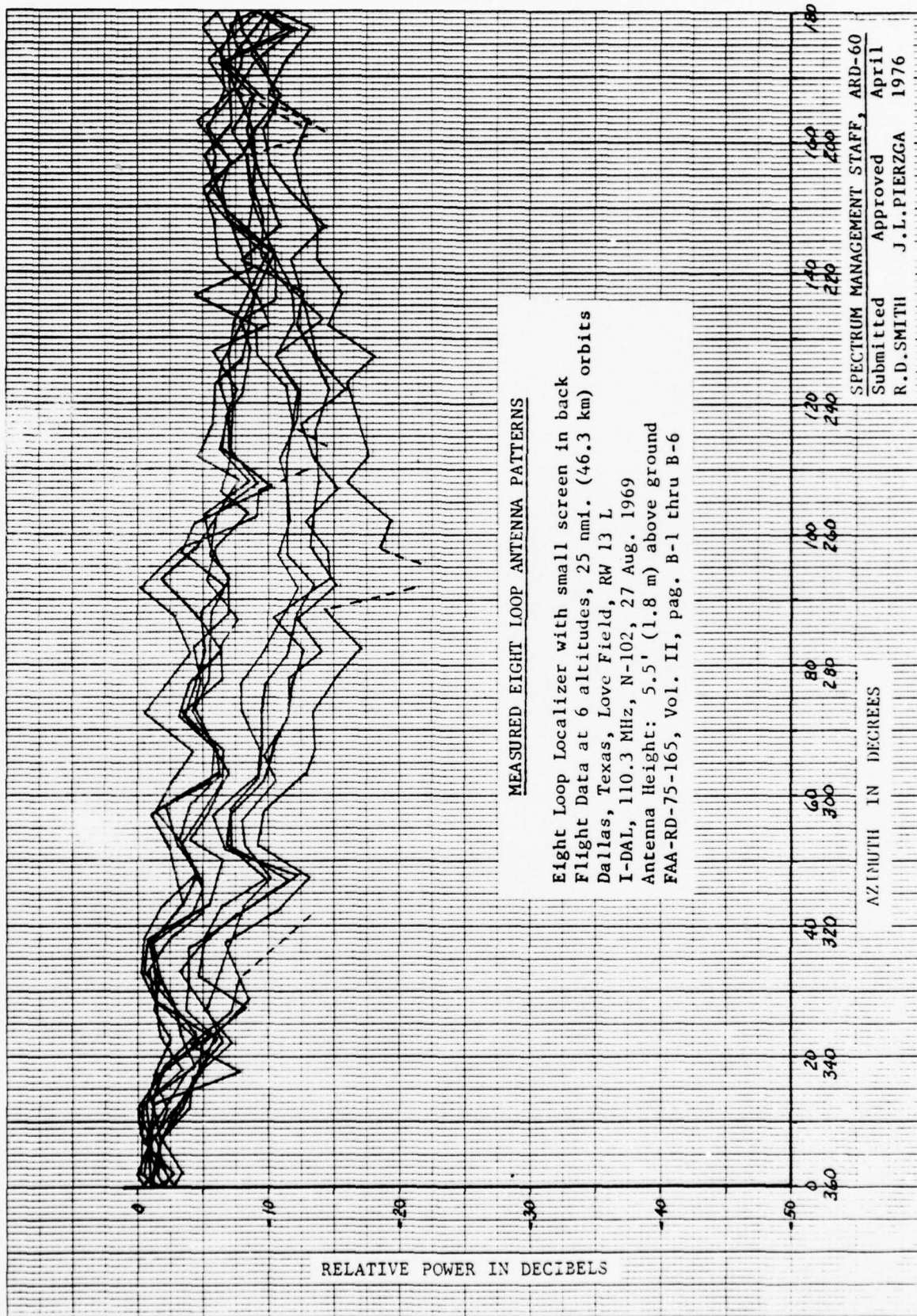


FIGURE E 3

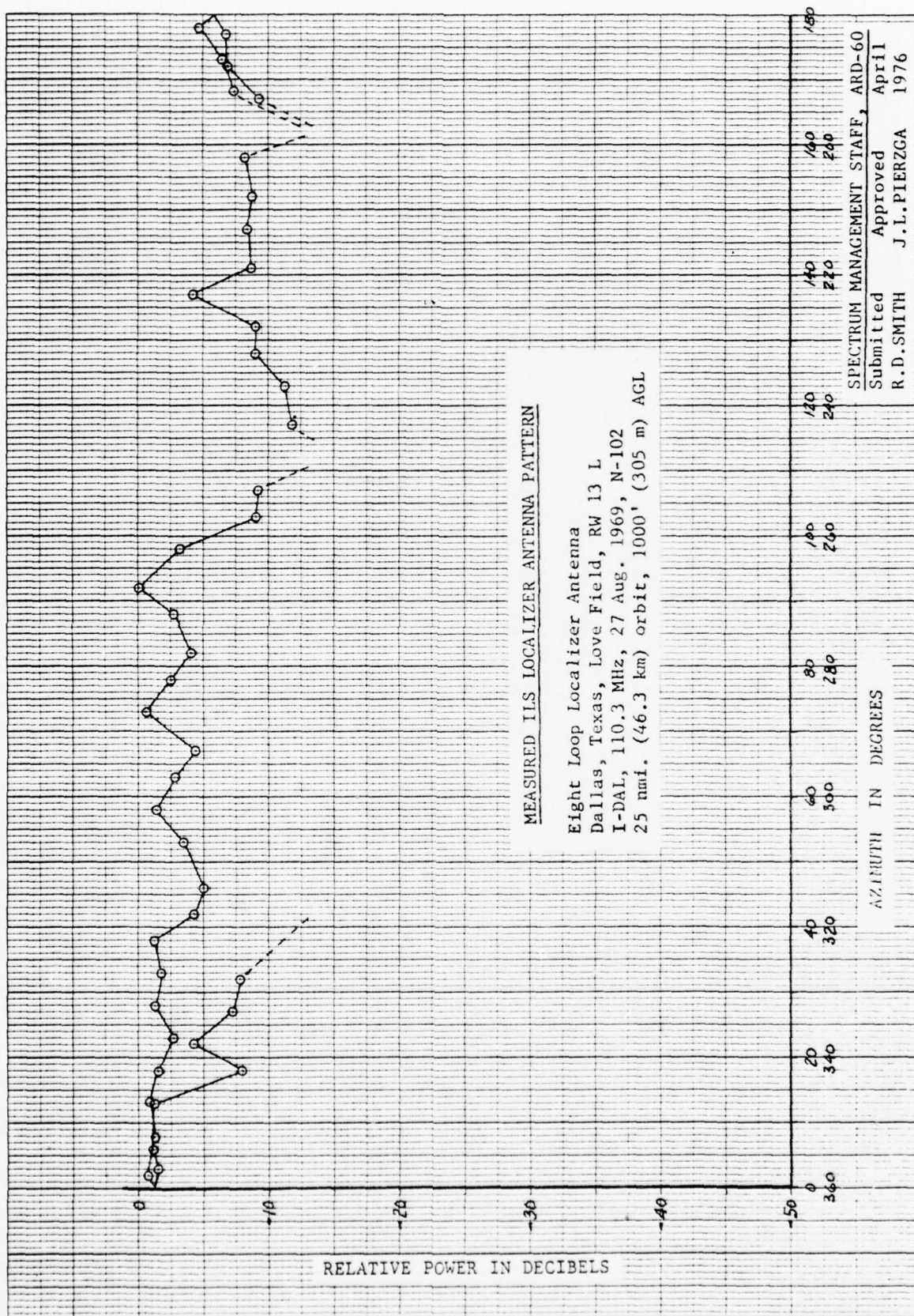


FIGURE E 4

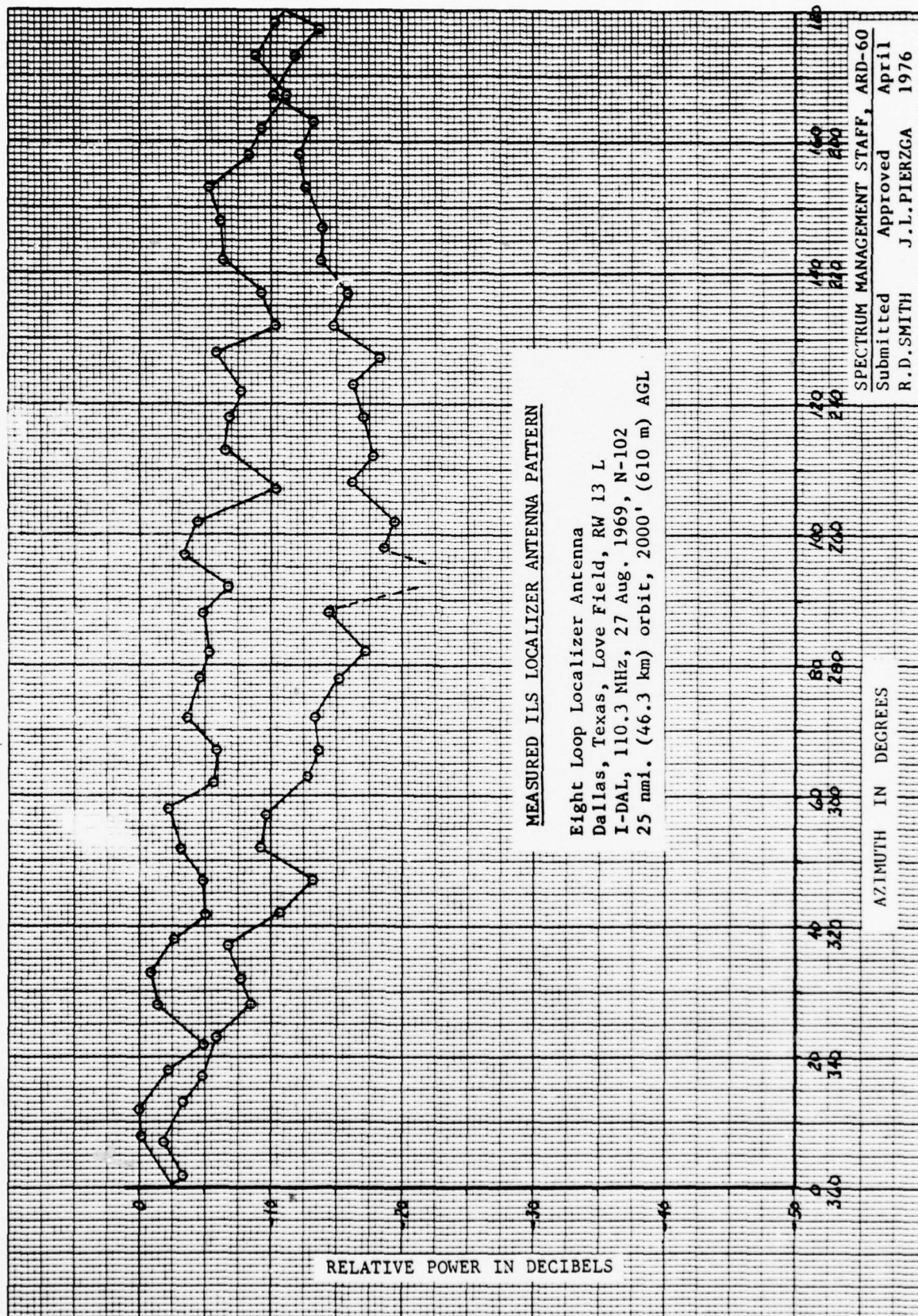


FIGURE E 5

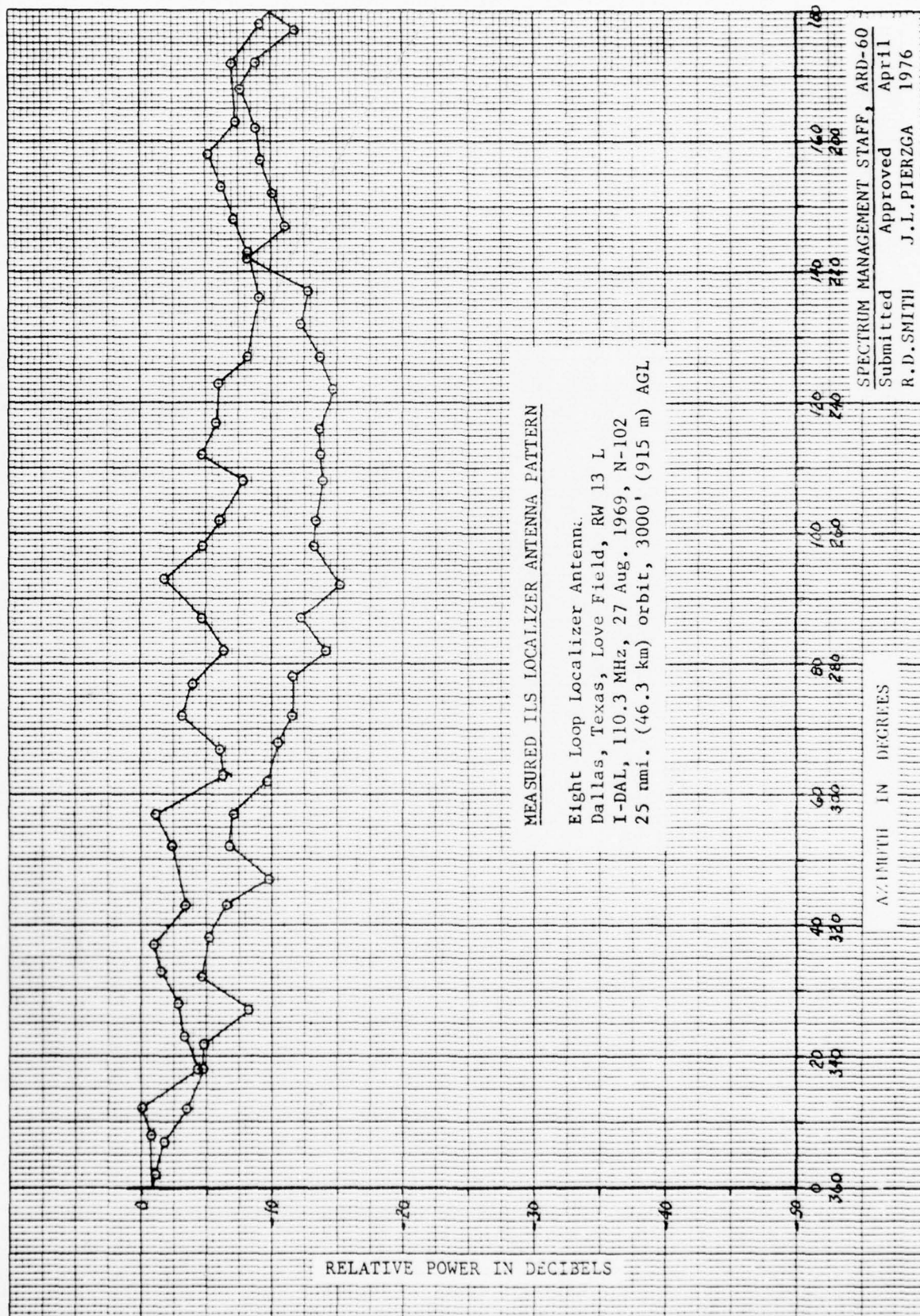


FIGURE E 6

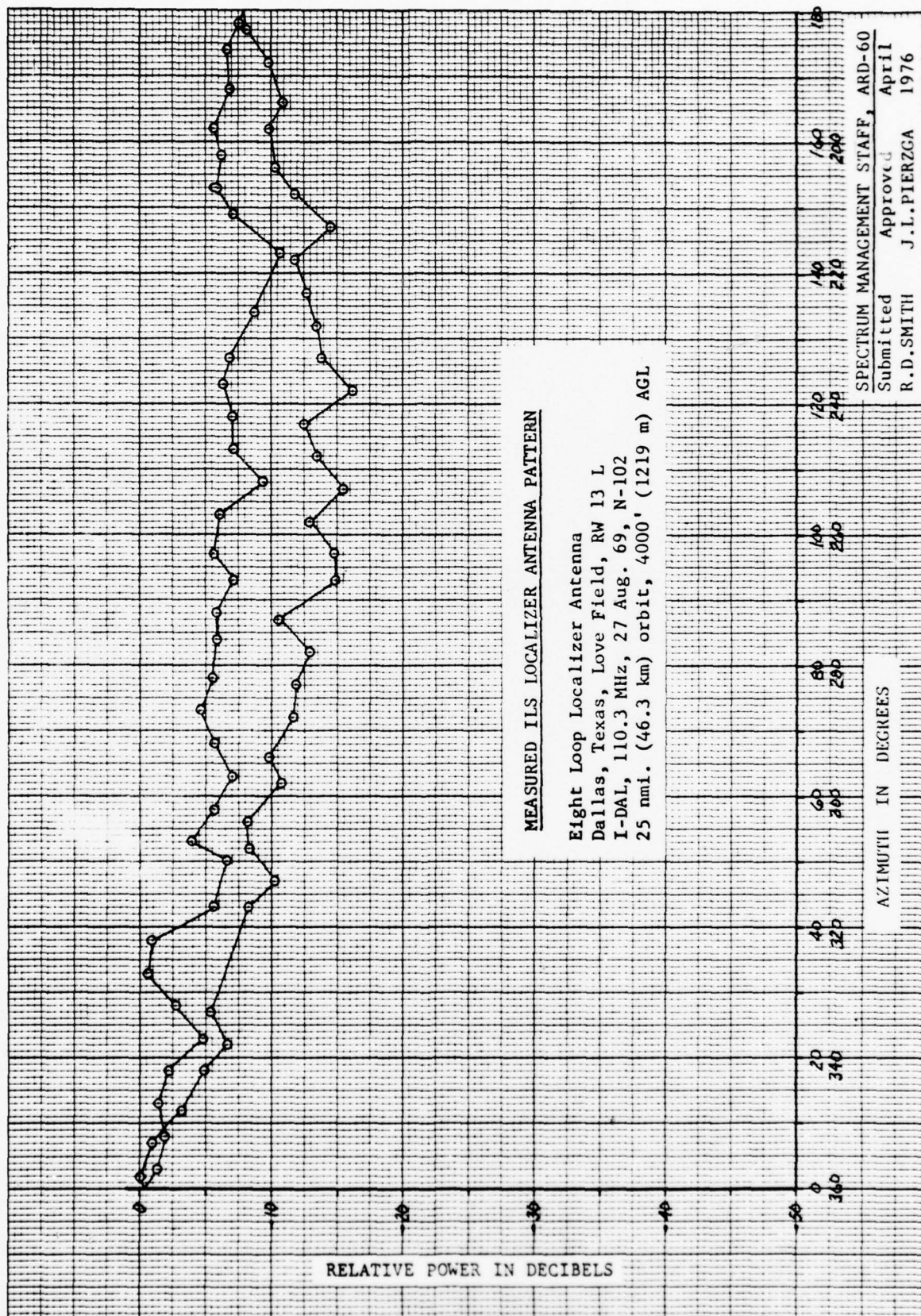


FIGURE E 7

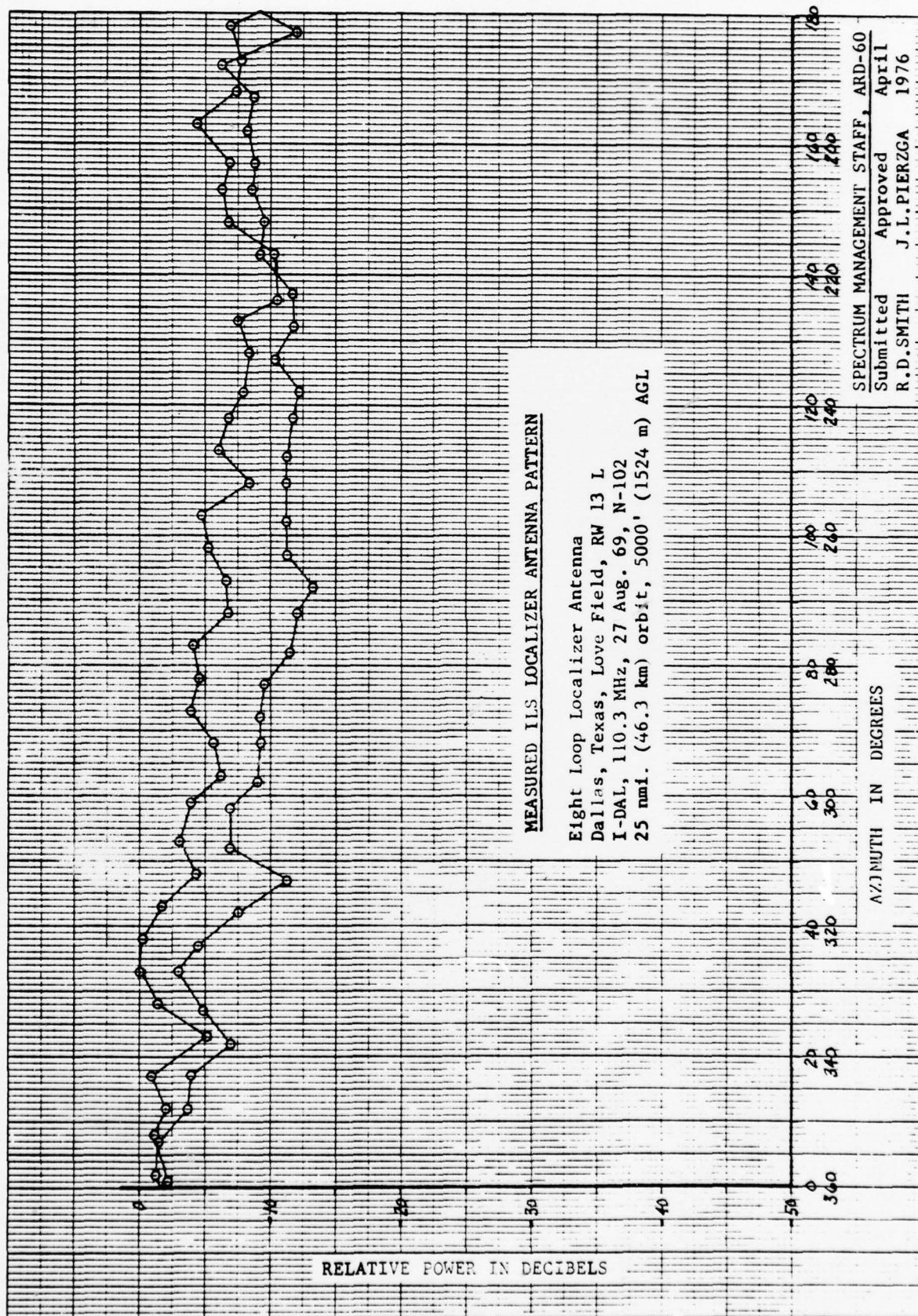
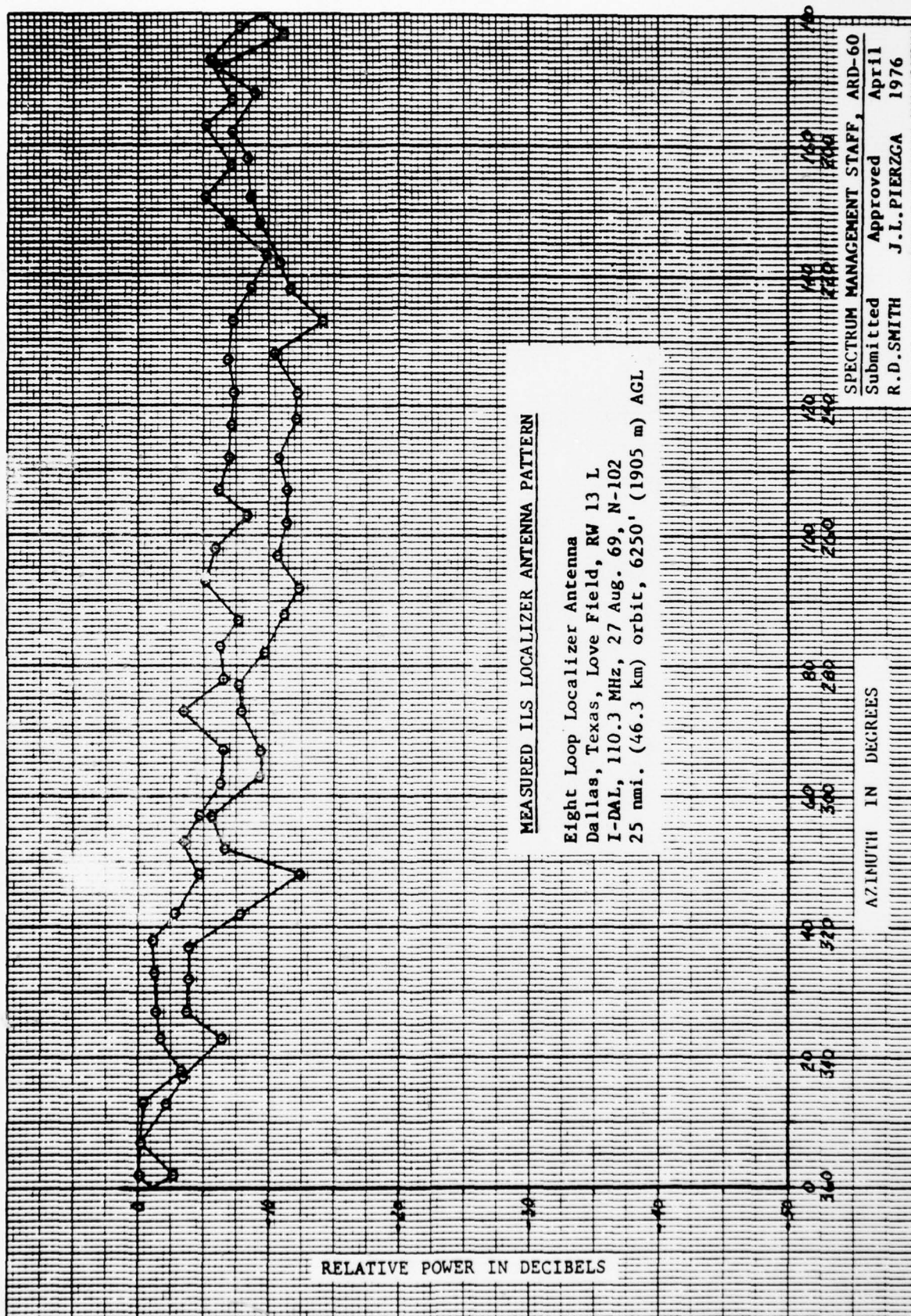


FIGURE E 8



APPENDIX F

WILCOX LOG PERIODIC DIPOLE

OPTION 1, EIGHT ELEMENT ARRAY

Of the two similar systems made by Wilcox, this is the narrow aperture array. It consists of eight log periodic dipole (LPD) antenna elements, each mounted on the break-away supports. Each element consists of seven parallel, horizontally polarized, dipole radiators. This is a single frequency array.

An antenna pattern (Figure F1) was obtained from the manufacturer (Reference 29). The FAA measured data (Figures F2, B3 and B4) show good agreement within ± 45 degrees. Beyond this point, substantial differences are apparent. This is largely due to the way that each of the patterns was obtained. The manufacturer pattern is a computer presentation based on data obtained on an antenna range. A single antenna element is placed on a movable platform. The platform is then rotated and a measurement of the radiated signal is taken at a ground test point. This results in an antenna pattern for a single element at an elevation angle of zero degrees. Using this pattern and taking into consideration the amplitude and phasing of the signal fed to all the elements in the array, the computer predicts the antenna pattern of the array. Wilcox compared the computer results with measured data and found "good comparison." FAA also compared measured data with the computer results. Comparison was good within ± 45 degrees of the front course. From 45 to 180 degrees off course, there are substantial differences between measured data and the computer predictions. Measured data shows the antenna pattern to be less directive than the results of the model. While this appears to contradict the Wilcox results mentioned above, it may be a matter of how close the measured and predicted data need to be in order to have "good comparison."

Reference 23 claims that the LPD meets the requirements of Specification FAA-E-2492/2. The eight element array is covered by Option 1. The specification places upper and lower limits on the carrier pattern. The specification was modified in June 1975 (FAA-E-2492/2a). Slight changes were made to the upper limits and the lower limits were removed. This might lead one to believe that the manufacturer was having no difficulty staying below the upper limits but some difficulty in staying above the lower limits. A comparison between the

empirical data taken in January 1976, and the original specification shows this to be true for the front course of the antenna pattern but not for the back course. The manufacturer's data (taken at a zero degree elevation angle) show that the pattern meets the 26 dB front to back signal strength requirement by several dB. The FAA data (taken at a five degree element angle) show that the pattern misses this requirement by as much as 6 dB. This is taken into account in the frequency assignment antenna pattern (Figure 3).

OPTION 2, FOURTEEN ELEMENT ARRAY

This is the wide aperture LPD system. It consists of 14 LPD antenna elements, exactly like the elements in the narrow aperture array. This is also a single frequency array.

An antenna pattern (Figure F3) was obtained from the manufacturer (Reference 29). Although several Option 2 ground systems have been installed, no FAA data is available on the antenna pattern. Measured data would be very useful.

For this antenna, Specification FAA-E-2492/2a (Option 2) is applicable.

GRN-29V

This ILS is being procured by the U.S. Air Force. It uses a two-frequency, capture effect antenna made up of the same LPD element as the Options 1 and 2 antennas. According to the manufacturer, the power distribution and the phasing are different, resulting in a slightly tighter front course (one degree narrower at half power). Measured data would be very useful.

THEORETICAL ANTENNA PATTERN
WILCOX LOG PERIODIC DIPOLE

8 Element MK-I Self-Clearing Narrow
Aperature Array, FA-9359
3.0 Degree Course Width
Wilcox Computer Computation

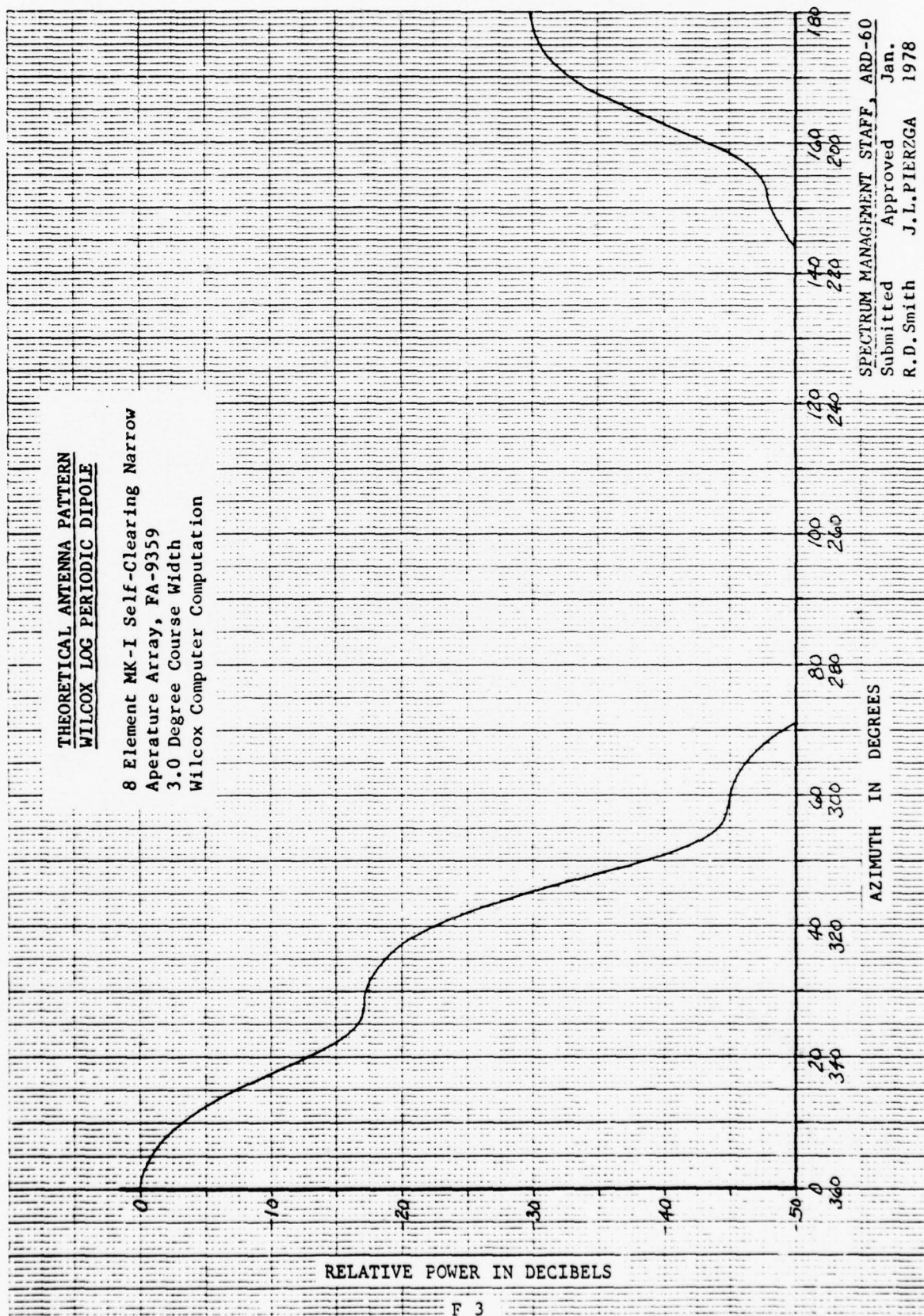


FIGURE F 1

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted R.D. Smith
Approved J.L. PIERZGA
Jan. 1978

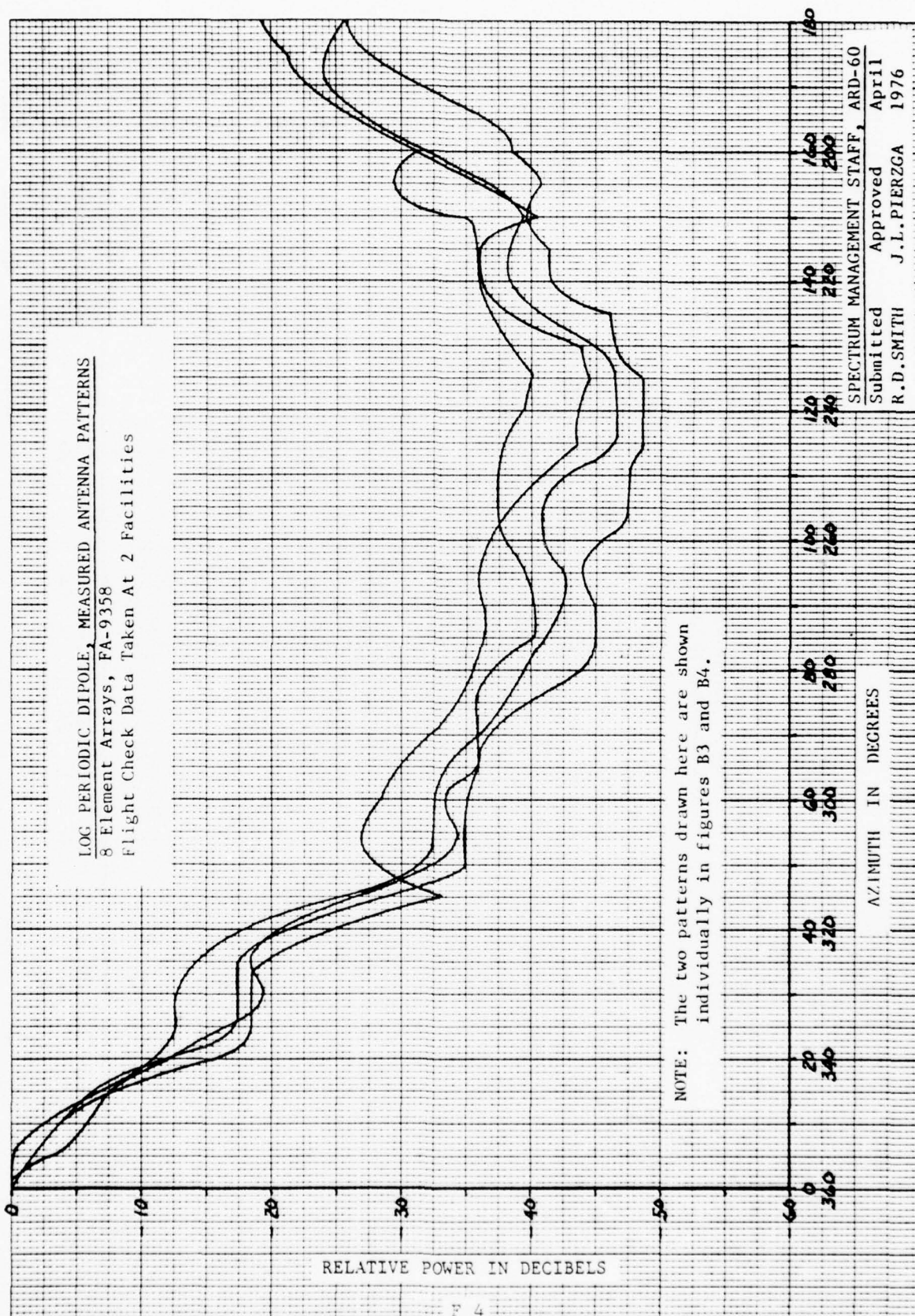
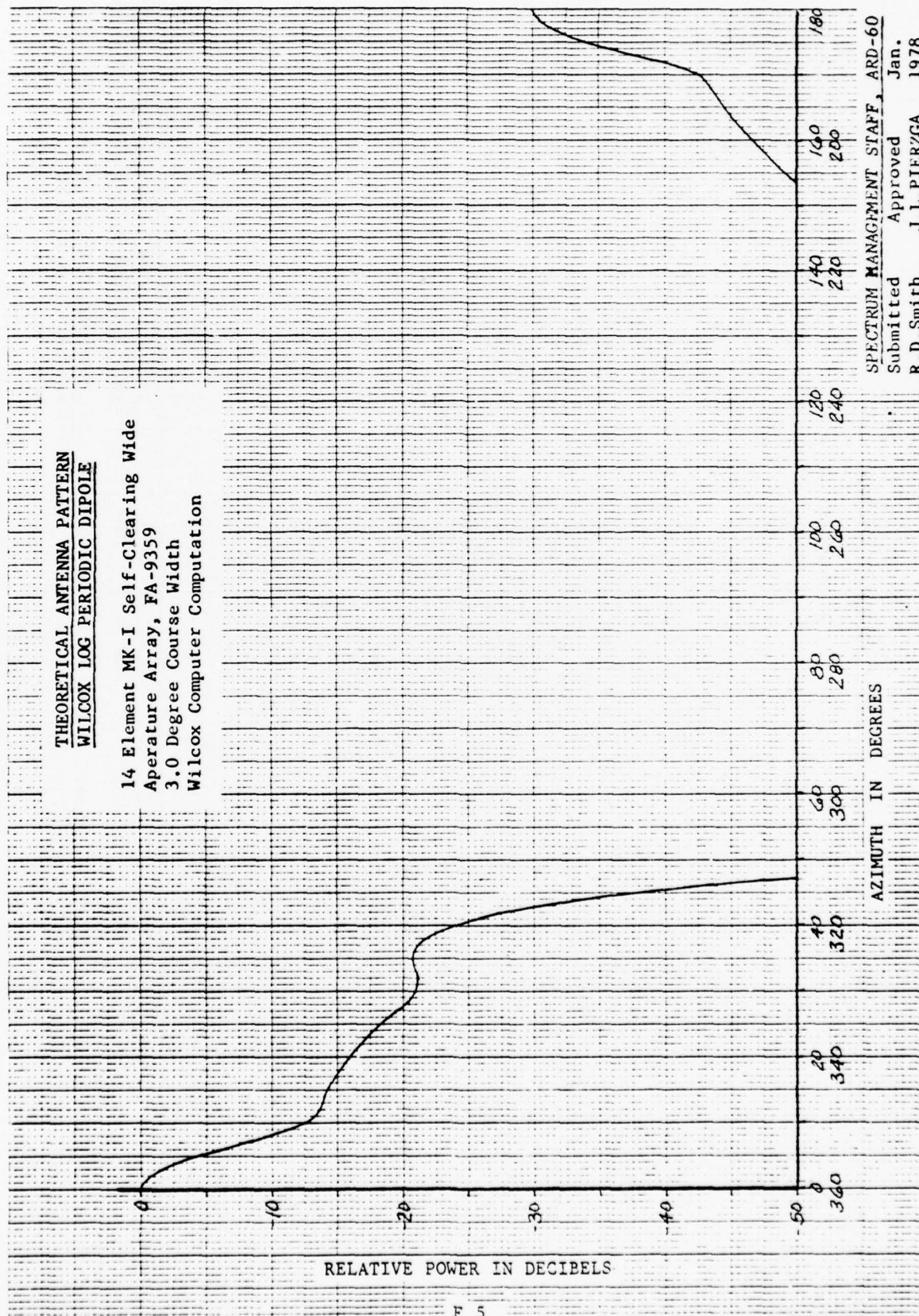


FIGURE F 2

THEORETICAL ANTENNA PATTERN
WILCOX LOG PERIODIC DIPOLE

14 Element MK-I Self-Clearing Wide
Aperature Array, FA-9359
3.0 Degree Course Width
Wilcox Computer Computation



SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted R.D. Smith
Approved J.L. PIERZGA
Jan. 1978

FIGURE F 3

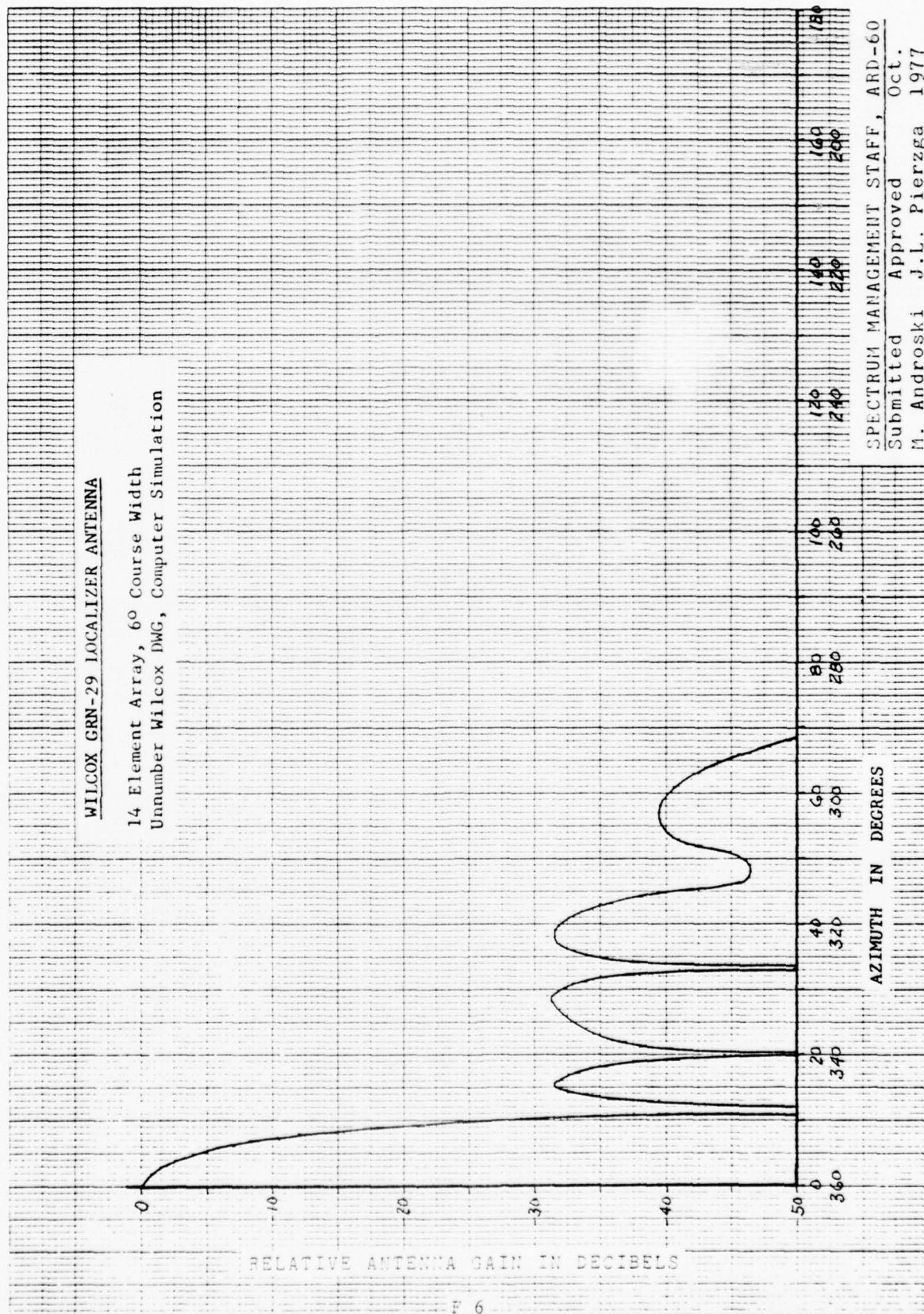


FIGURE F 4

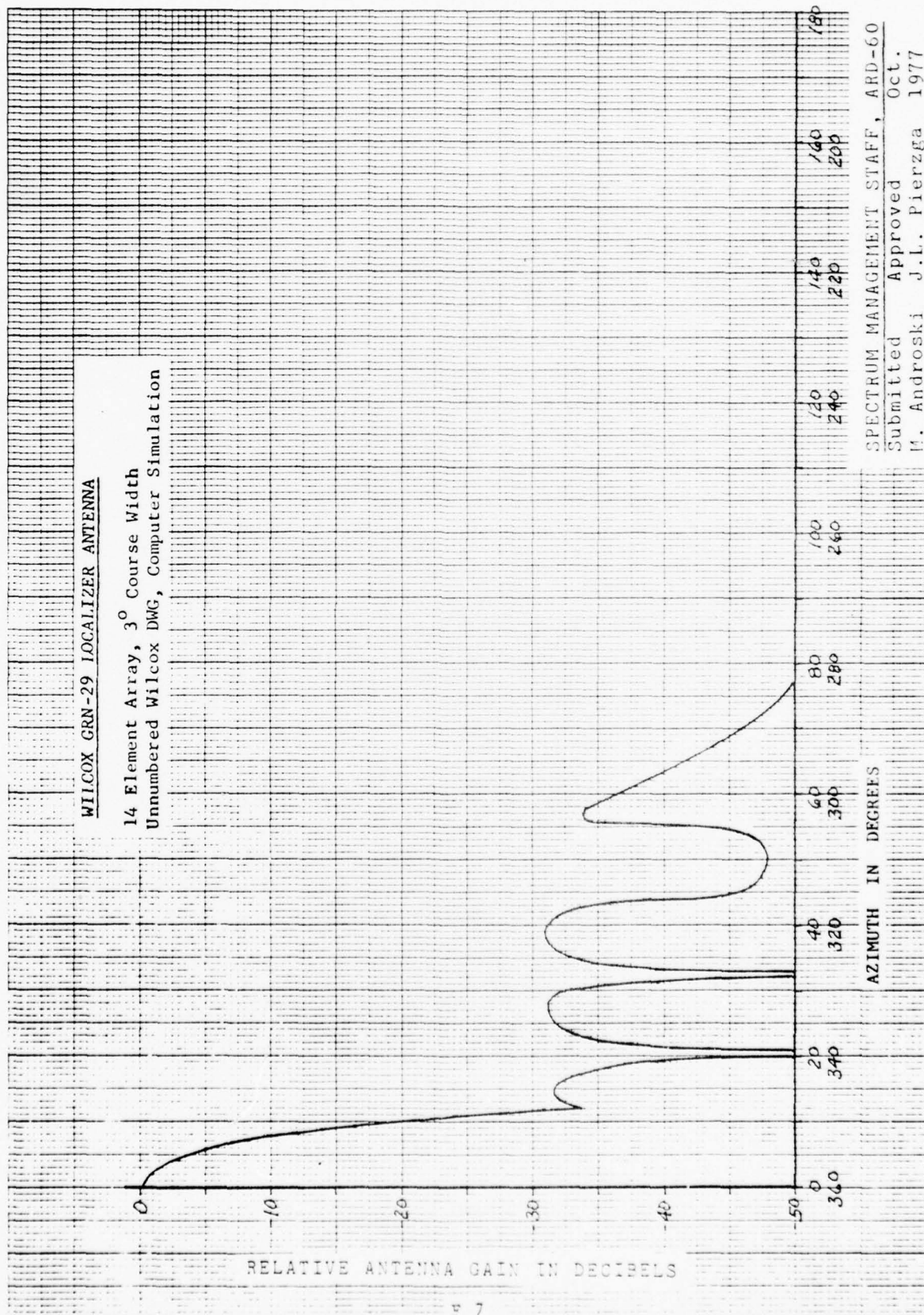


FIGURE F 5

APPENDIX G

MRN-7 ANTENNA

This is a two frequency, capture effect system, with approximately 10 kHz between frequencies. The course array consists of 12 half-wave dipole radiators, arranged in six symmetrical pairs. The clearance array consists of three dipoles with ends bent at a 90 degree angle. These radiators are mounted on a separate support located behind the course array.

Theoretical patterns for the course and clearance arrays were obtained from Military Technical Orders (Figure G1). The measured data taken (Figures G2, B5, B6 and B7) includes spectrum analyzer measurements as well as AGC measurements. This allows a direct comparison of individual course and clearance patterns, theoretical and measured. Within the appropriate tolerances, the patterns show good comparison.

This is primarily a military system and no FAA specifications on antenna patterns were found to be applicable. A large number of the systems were installed some years ago and many still remain.

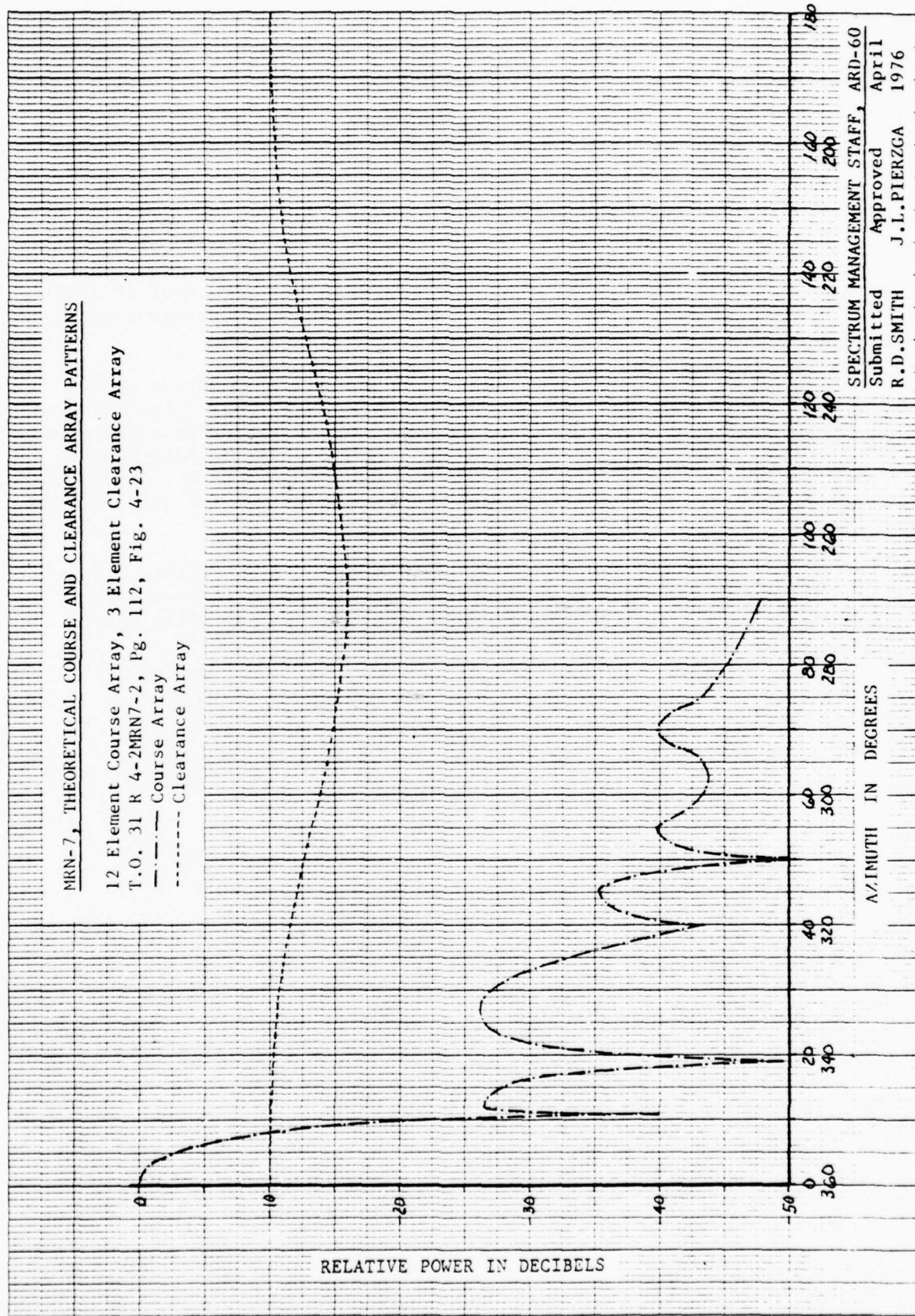


FIGURE G 1

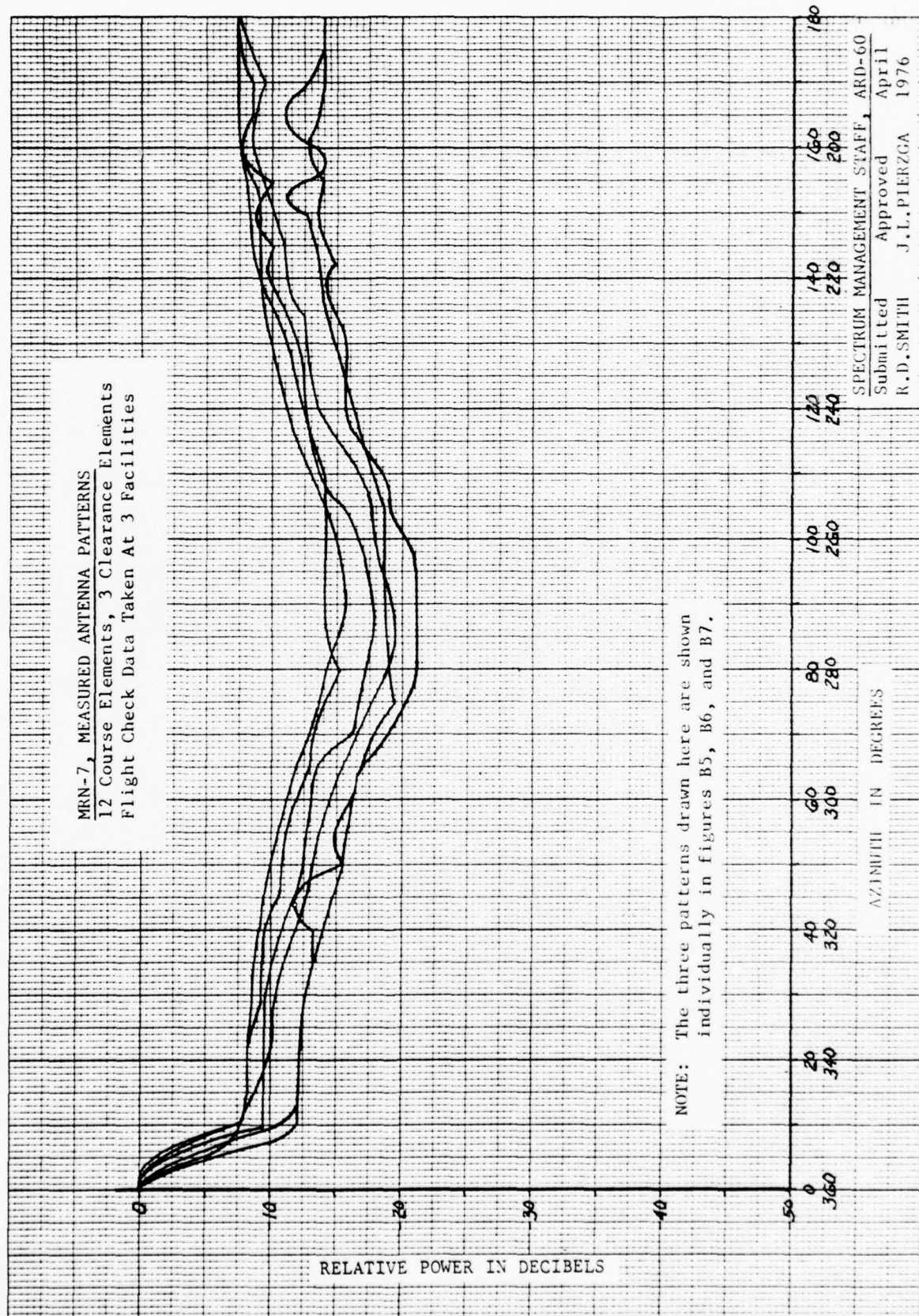


FIGURE G 2

APPENDIX H
PARABOLIC ANTENNA ARRAYS

T.I. Regular Parabolic Array (5/3) (Type 3)

This is a two frequency, capture effect system, with 9.5 kHz between frequencies. The course array has three elements and a parabolic reflector.

The parabola has an aperture of 116 feet, is uniformly 13.5 feet high, and has a focal plane 29.5 feet from the reflector. It is constructed of steel tubes and horizontal stretched copper wires which constitute the reflecting surface. The antenna exciter consists of three directional antennas located at the parabola focus. The center exciter, located on the parabola axis, is a three-element V-frame type consisting of a reflector, a radiator, and a director. The two lateral exciters, located at equal distances on each side of the parabola axis, are also V-frame type antennas consisting of a radiator and a reflector.

The clearance array consists of five V-frame elements located about 63 feet in front of the focus. Clearance signal is fed into the course array 180 degrees out of phase. It is this which causes the substantial dip in the clearance array signal within ± 30 degree that is seen in the data taken at McGuire AFB in January 1976 (Figure B9).

Theoretical data has been obtained from the manufacturer (Figure H1). It compares fairly well with measured data, although some differences are seen in the clearance arrays between 45 and 90 degrees. Unfortunately, no theoretical data was available beyond 90 degrees.

About 72 of this system have been bought by the Air Force to date. No FAA specifications were found to be applicable to the radiation patterns of this antenna.

T.I. Wide Aperture Parabola (4/3) (Type 4)

This is also a two frequency, capture effect antenna, with 9.5 kHz between frequencies. It is quite similar in appearance to the regular parabola. It is 176 wide, uniformly 18 feet high, and has a focal plane 44 feet from the reflector. The system has four V-frame clearance elements and three V-frame course elements. No clearance data is fed into the course array and the dip in the clearance on course is not as substantial. The FAA has installed this system at NAFEC, Atlanta, and San Francisco.

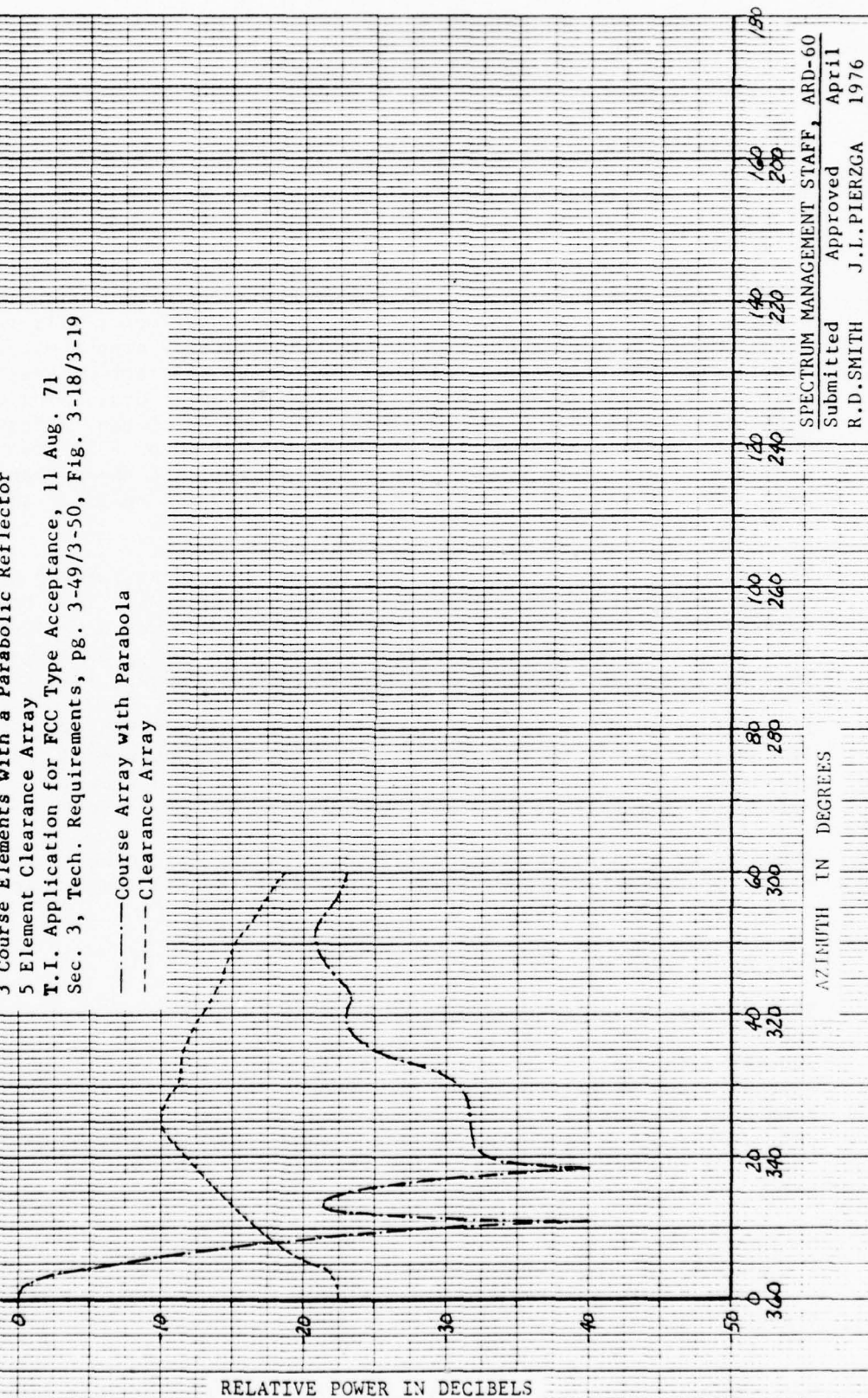
Measured data taken at NAFEC in January 1976 was compared with theoretical data obtained from the manufacturer (Figure H3). Although no theoretical data was available from 90 to 180 degrees, the information which was available compared well with the measured data.

Only three of this system are known to be installed at this time. No FAA specifications were found to be applicable to the radiated antenna patterns of this antenna.

T.I. NARROW APERATURE PARABOLIC ANTENNA (5/3)
THEORETICAL COURSE AND CLEARANCE PATTERNS

3 Course Elements with a Parabolic Reflector
 5 Element Clearance Array
 T.I. Application for FCC Type Acceptance, 11 Aug. 71
 Sec. 3, Tech. Requirements, pg. 3-49/3-50, Fig. 3-18/3-19

-----Course Array with Parabola
 -----Clearance Array



SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D.SMITH
 Approved J.L.PIERZGA
 April 1976

FIGURE H 1

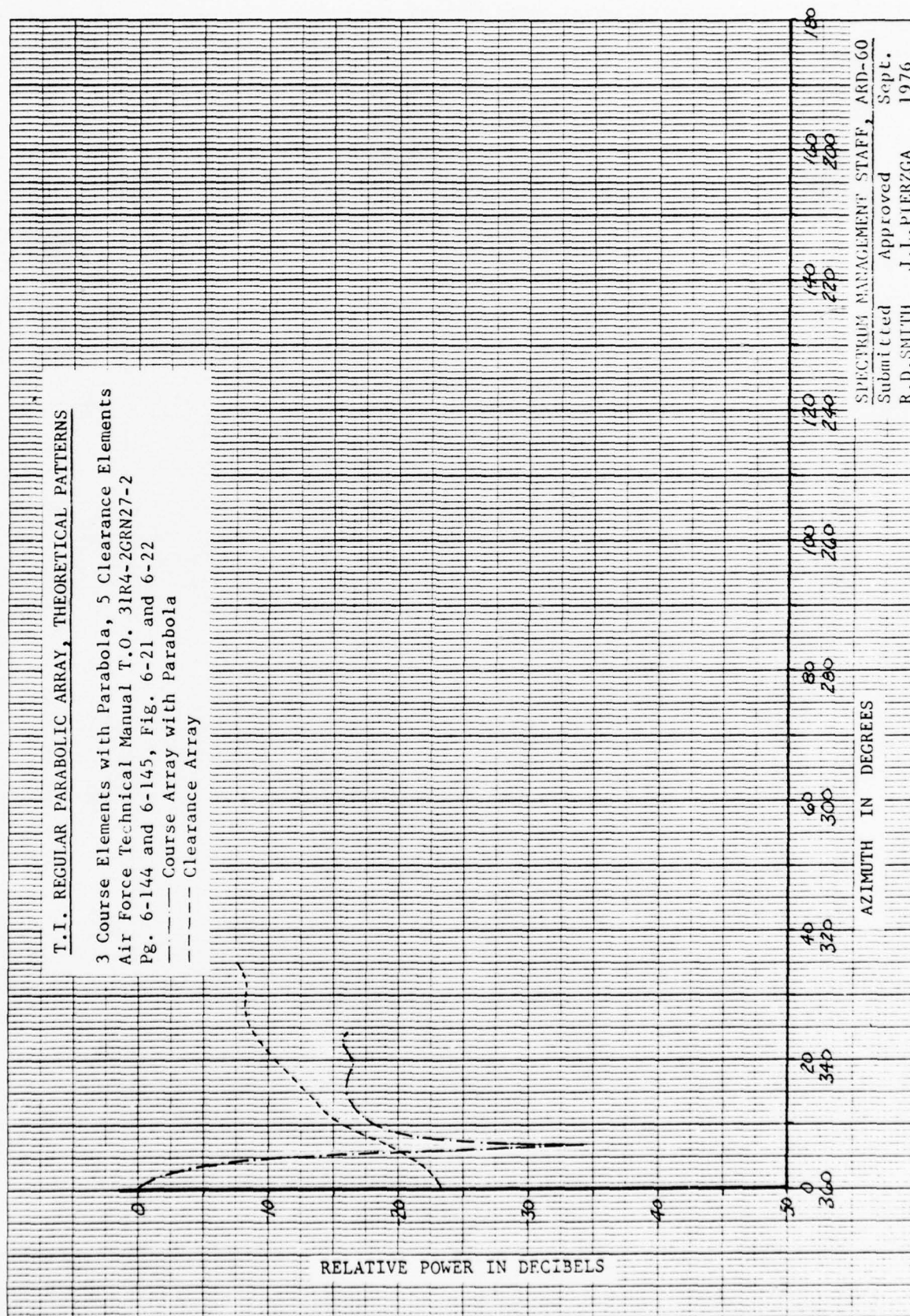


FIGURE H 2

T.I. WIDE APERATURE PARABOLIC ARRAY, THEORETICAL ANTENNA PATTERN

3 Course Elements with Parabola, 4 Clearance Elements
T.I. Application for FCC Type Acceptance, 11 Aug 71
Section 3.0, Technical Requirements, Pg. 3-67/3-68, Fig. 3-24
--- Course Array with Parabola
----- Clearance Array

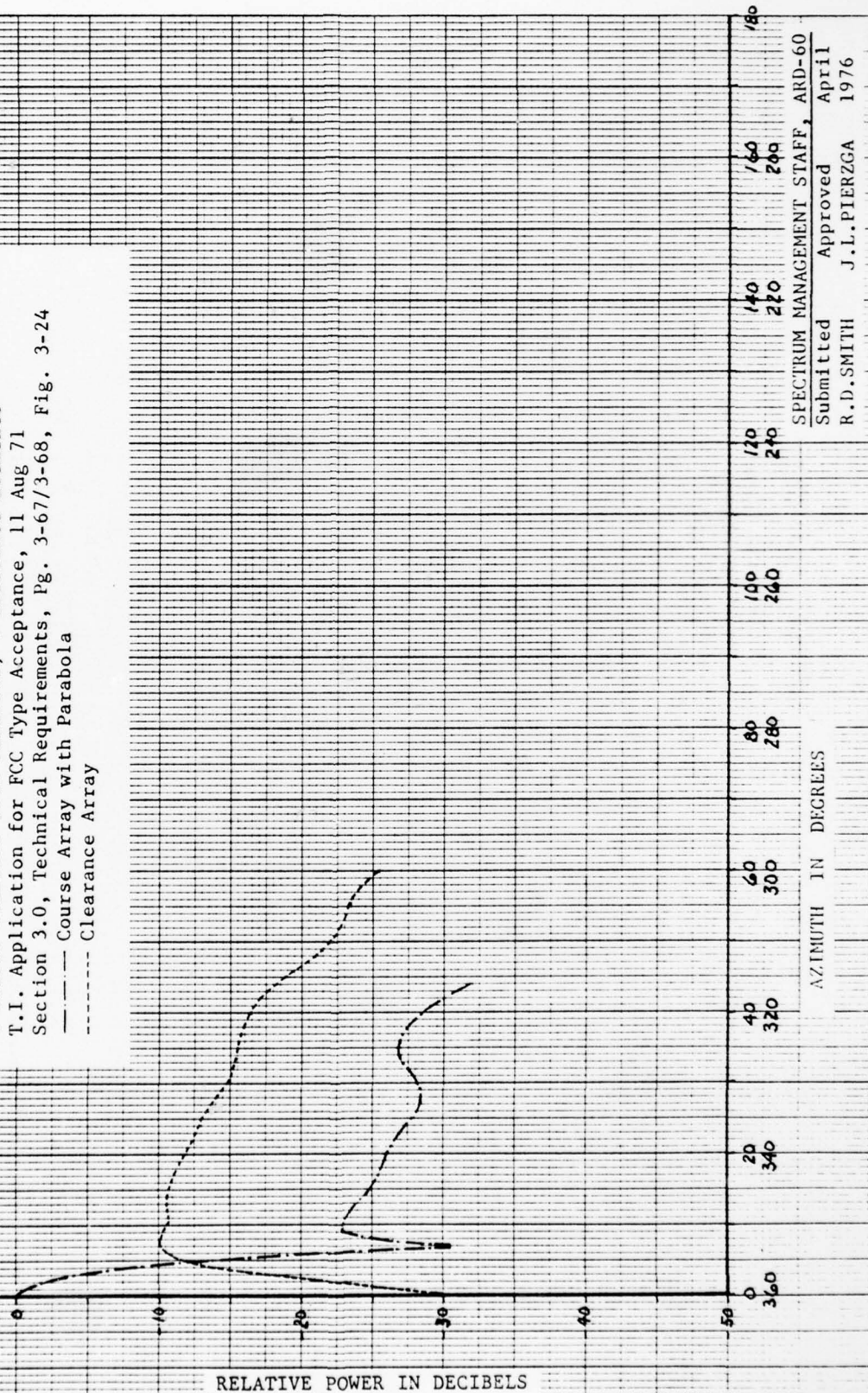
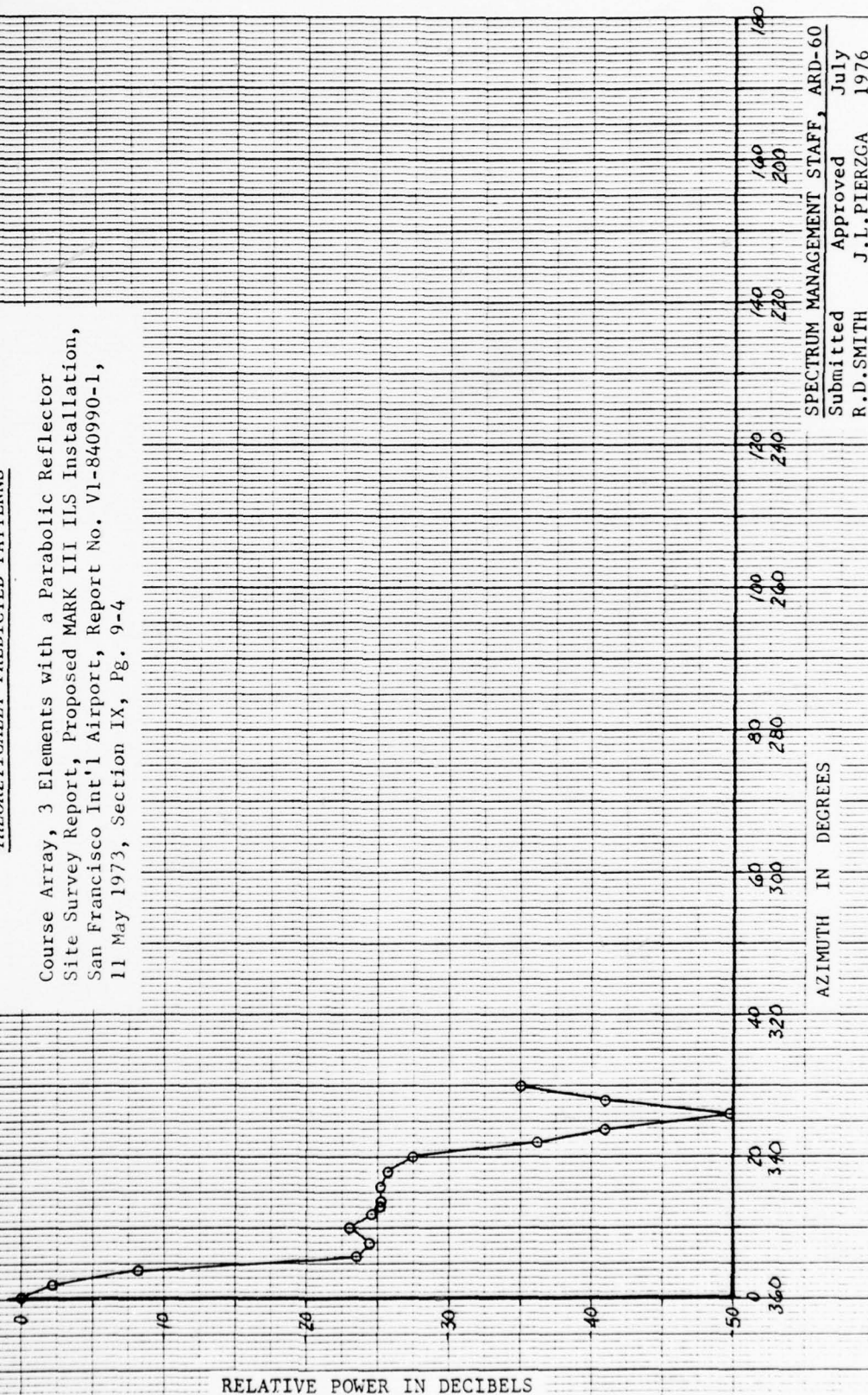


FIGURE H 3

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted R.D.SMITH J.L.PIERZGA
Approved April 1976

T.I. WIDE APERATURE PARABOLIC ANTENNA ARRAY
THEORETICALLY PREDICTED PATTERNS

Course Array, 3 Elements with a Parabolic Reflector
 Site Survey Report, Proposed MARK III ILS Installation,
 San Francisco Int'l Airport, Report No. VI-840990-1,
 11 May 1973, Section IX, Pg. 9-4



SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D.SMITH
 Approved J.L.PIERZGA
 July 1976

FIGURE H 4

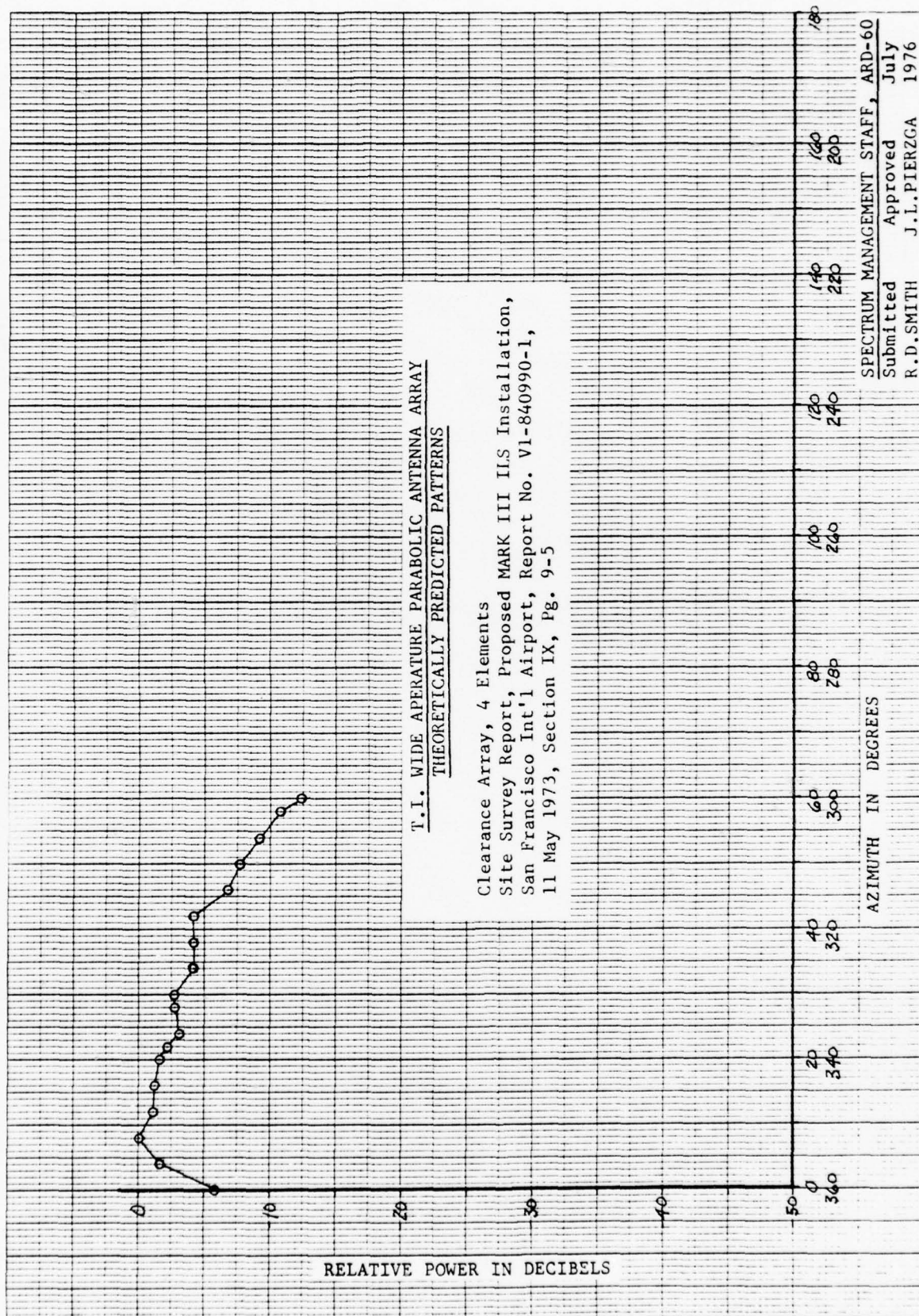
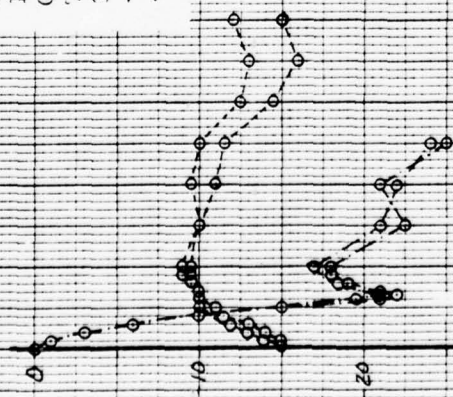


FIGURE H 5

I.L.S. ANTENNA PATTERN

San Francisco, CA, International Airport RW 28R
 I-CWQ, 111.7 MHz
 Ground Measurements Taken at 1 Km, 30 July 75
 T.I. Wide Aperature Parabolic Array, Type 4
 3 Course Elements with Parabola, 4 Clearance Elements
 --- Course Array
 --- Clearance Array



RELATIVE POWER IN DECIBELS

SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D.SMITH
 Approved J.L.PIERZGA
 July 1976

FIGURE H 6

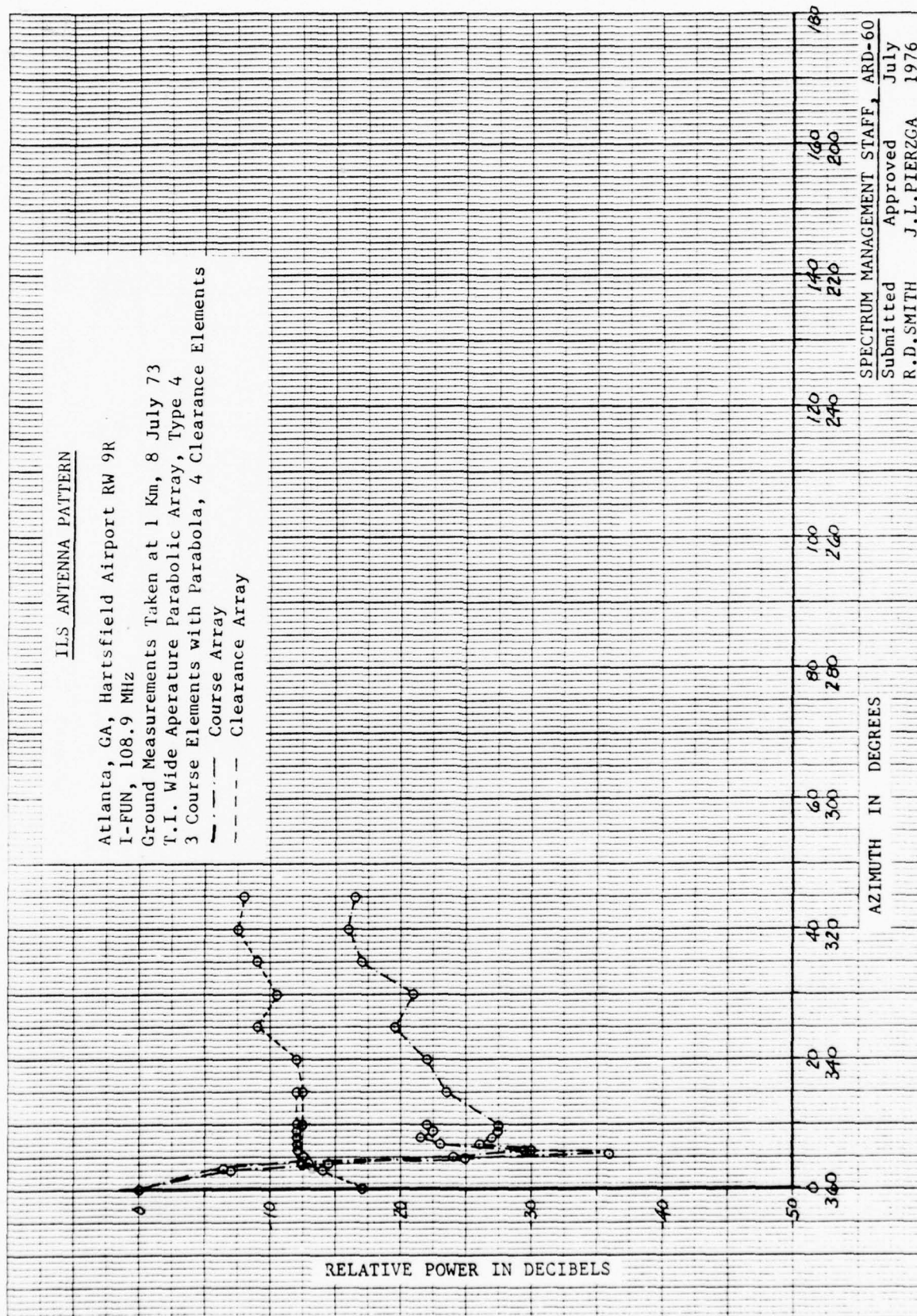
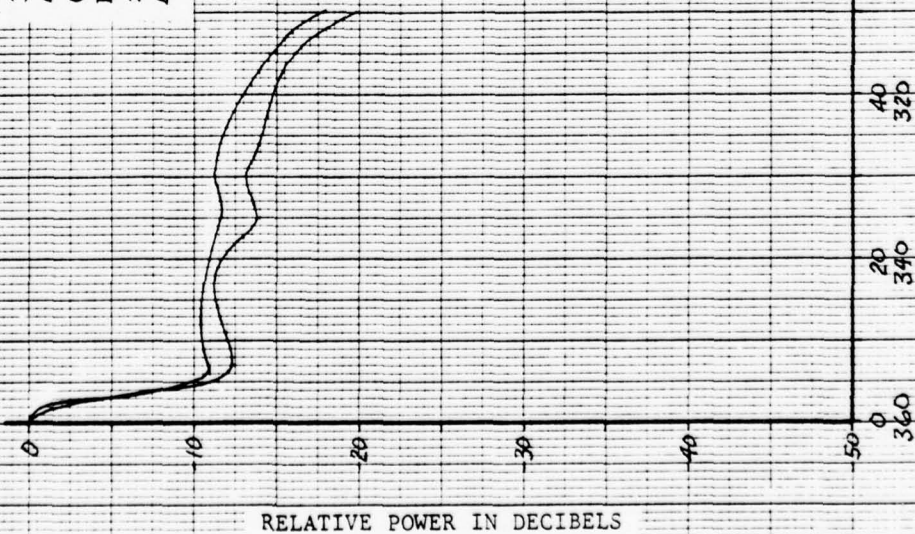


FIGURE H 7

MEASURED LOCALIZER ANTENNA PATTERN
T.I. WIDE APERATURE PARABOLIC ARRAY

3 Course Elements with a Parabolic Reflector
 4 Clearance Elements, NAFEC, 12 Feb. 73
 6 nmi. (11.1 km) orbit, 6000' (1529 m) AGL
 Progress Report: Course Bend Analysis
 for Runway 28 R, San Francisco Int'l
 Airport, 24 Mar. 73; Alford Dwg. No. A334-5015



SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D.SMITH Approved J.L.PIERZGA July 1976

FIGURE H 8

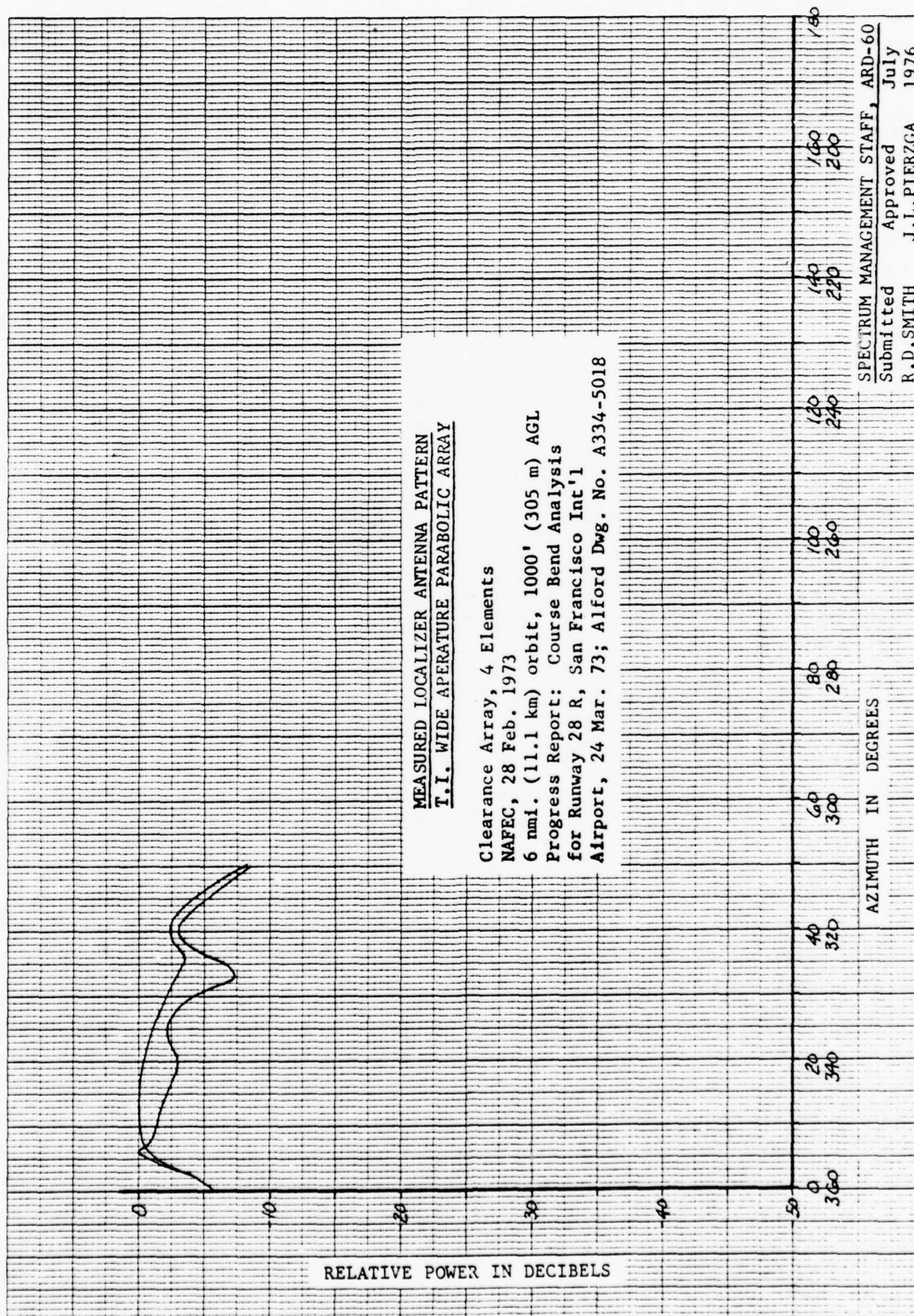
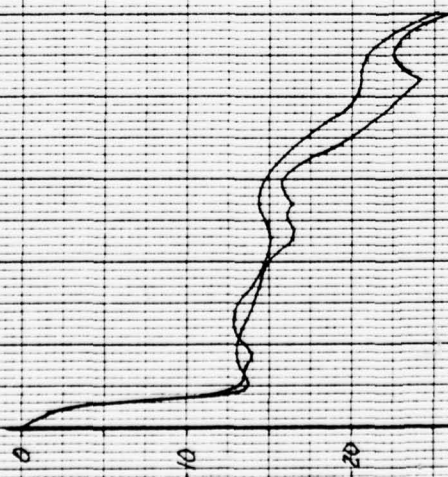


FIGURE H 9

MEASURED LOCALIZER ANTENNA PATTERN
T.I. WIDE APERATURE PARABOLIC ARRAY

Atlantic City, N. J., NAFEC, RW 13
 I-PVO, 109.1 MHz, Partial Orbit
 6 nmi. (11.1 km), 6000' (1529 m) AGL
 Bendix RCVR 4165.3A, SN 1074, N-114
 FAA-RD-74-180, pg. B-13, Fig. B-10



RELATIVE POWER IN DECIBELS

SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted Approved
 R. D. SMITH J. I. PIERZGA
 Oct. 1976

FIGURE H 10

T. I. NARROW APERATURE PARABOLIC ANTENNA (5/3)
MEASURED COURSE AND CLEARANCE PATTERNS

Seattle, Wash., Seattle-Tacoma Intl. RW 16R
 I-SZI, 110.3 MHz, Aug. 1976

----- Course Array with Parabola
 ----- Clearance Array

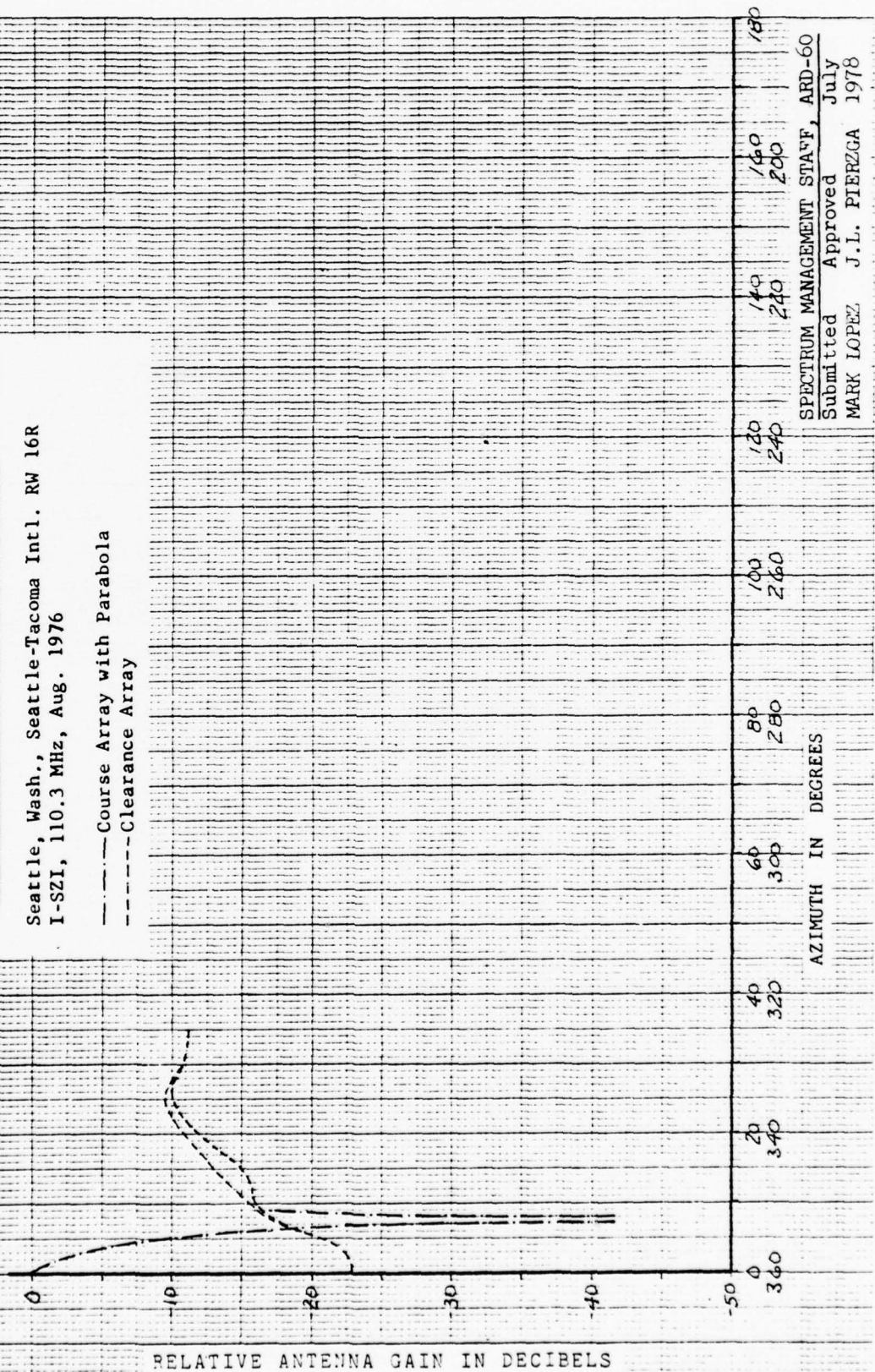


FIGURE H 11

SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted Approved July
 MARK LOPEZ J.L. PIERZGA 1978

APPENDIX I

STAN-37 ANTENNA

The STAN-37 localizer and STAN-38 glideslope are the major components of a British ILS system. Presently, the only one commissioned in the U.S. is located at Dulles Airport. With the difficulties and expense involved in obtaining replacement parts, it is unlikely that there will be any others. Although airborne measurements were taken on a waveguide antenna at Dulles in January, none were taken for the STAN-37. For frequency management purposes, it is difficult to justify the expense of making airborne measurements on a one-of-a-kind localizer. The radiation patterns enclosed for the STAN-37 were taken from the results of a joint test by the U.S. and the U.K. (Reference 12) and from an unpublished data package showing results of tests on NAFEC Runway 13 (Reference 13).

The STAN-37 localizer has a 12-element course array with diplexed clearance. Twelve horizontal dipoles are located within a corner reflector framework. In this system, capture effect at the aircraft receiver is obtained due to the fact that the 90 Hz and the 150 Hz tones of the course array are in low frequency quadrature with the 90 Hz and 150 Hz tones of the clearance system. Crossover from clearance to course occurs at ± 8 degrees.

No FAA specifications are known to apply to this system.

STAN 37 LOCALIZER ANTENNA
 Course and Clearance Arrays
 U.K. Instruction Manual, TTH 309
 H'B 1268/1A, Sect. 7, ISS.1,
 March 1967, Figure 7/2

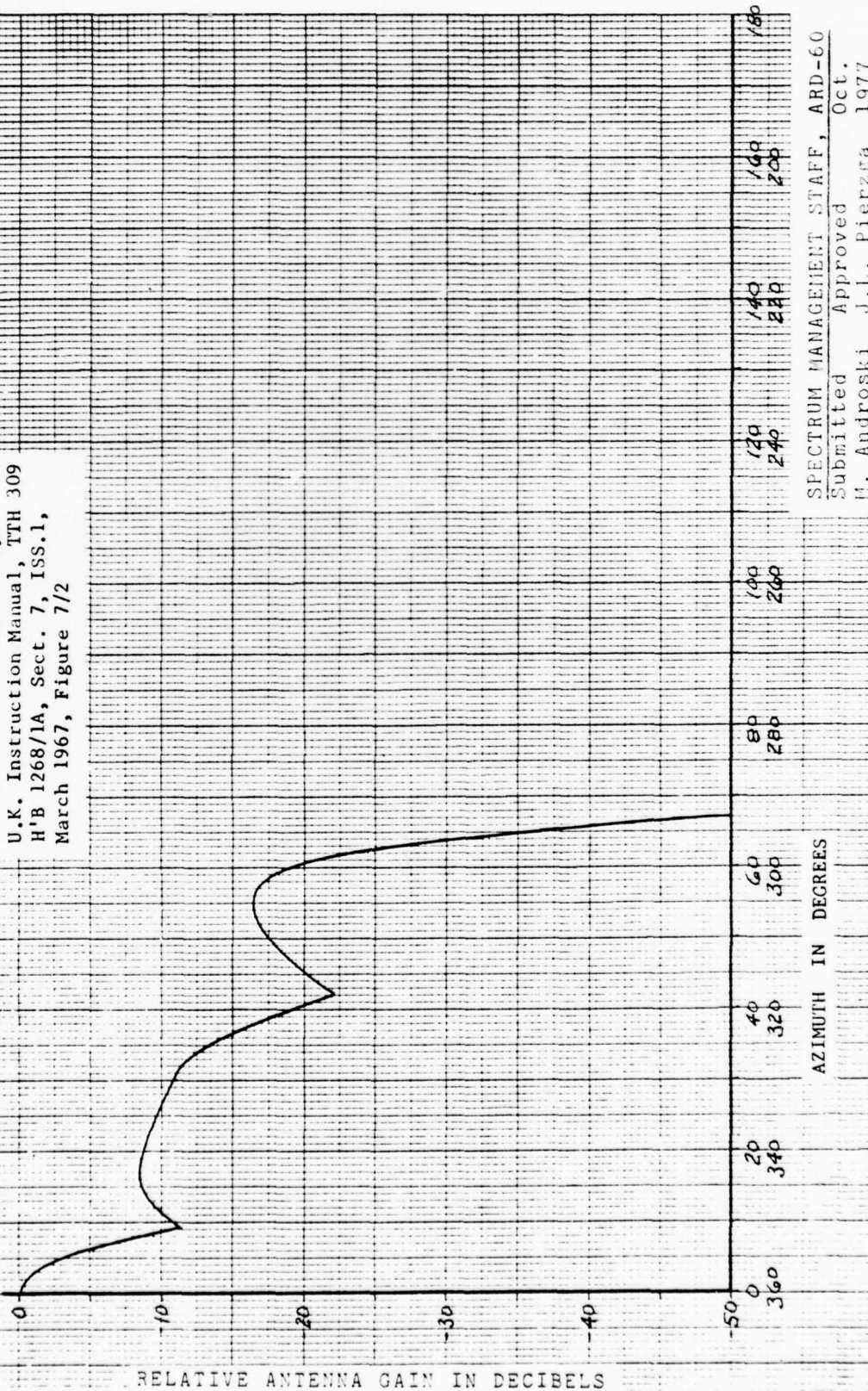


FIGURE I 1

SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted Approved Oct.
 M. Androski J.L. Pierzga 1977

-37 LOCALIZER ANTENNA

Measured Data, Course and Clearance Array
Atlantic City, N. J., NAFEC, RW 4
108.1 MHz, N-247
6 nmi (11.1 km) Orbit, 6000' (1830 m) AGL
Report No. FAA-RD-72-50, Figs. 53 and 55

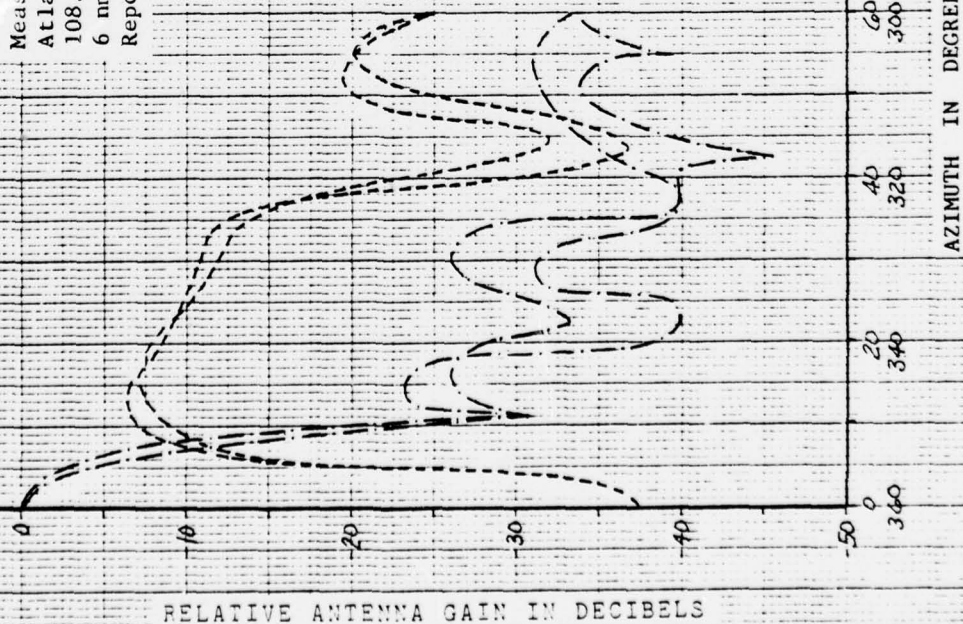
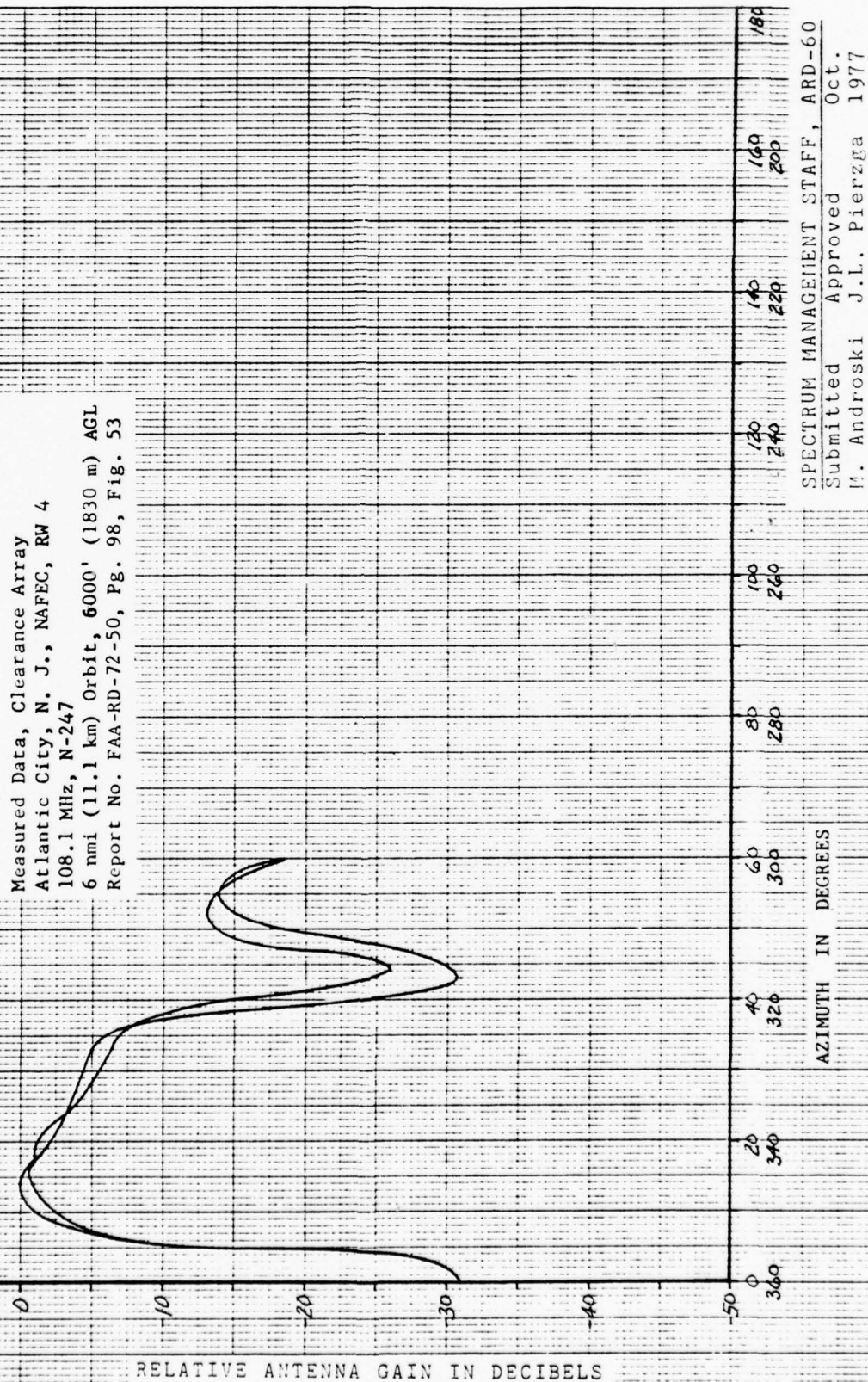


FIGURE I 2

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted Approved Oct.
M. Androski J.L. Pierzga 1977

STAN-37 LOCALIZER ANTENNA

Measured Data, Clearance Array
Atlantic City, N. J., NAFEC, RW 4
108.1 MHz, N-247
6 nmi (11.1 km) Orbit, 6000' (1830 m) AGL
Report No. FAA-RD-72-50, Pg. 98, Fig. 53



SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted Approved Oct.
M. Androski J.L. Pierzga 1977

FIGURE I 3

STAN-37 LOCALIZER ANTENNA

Measured Data, Course Array
Atlantic City, N. J., NAFEC, RW 4
108.1 MHz, N-247
6 nmi (11.1 km) Orbit, 6000' (1830 m) AGL
Report No. FAA-RD-72-50, Pg. 100, Fig. 55

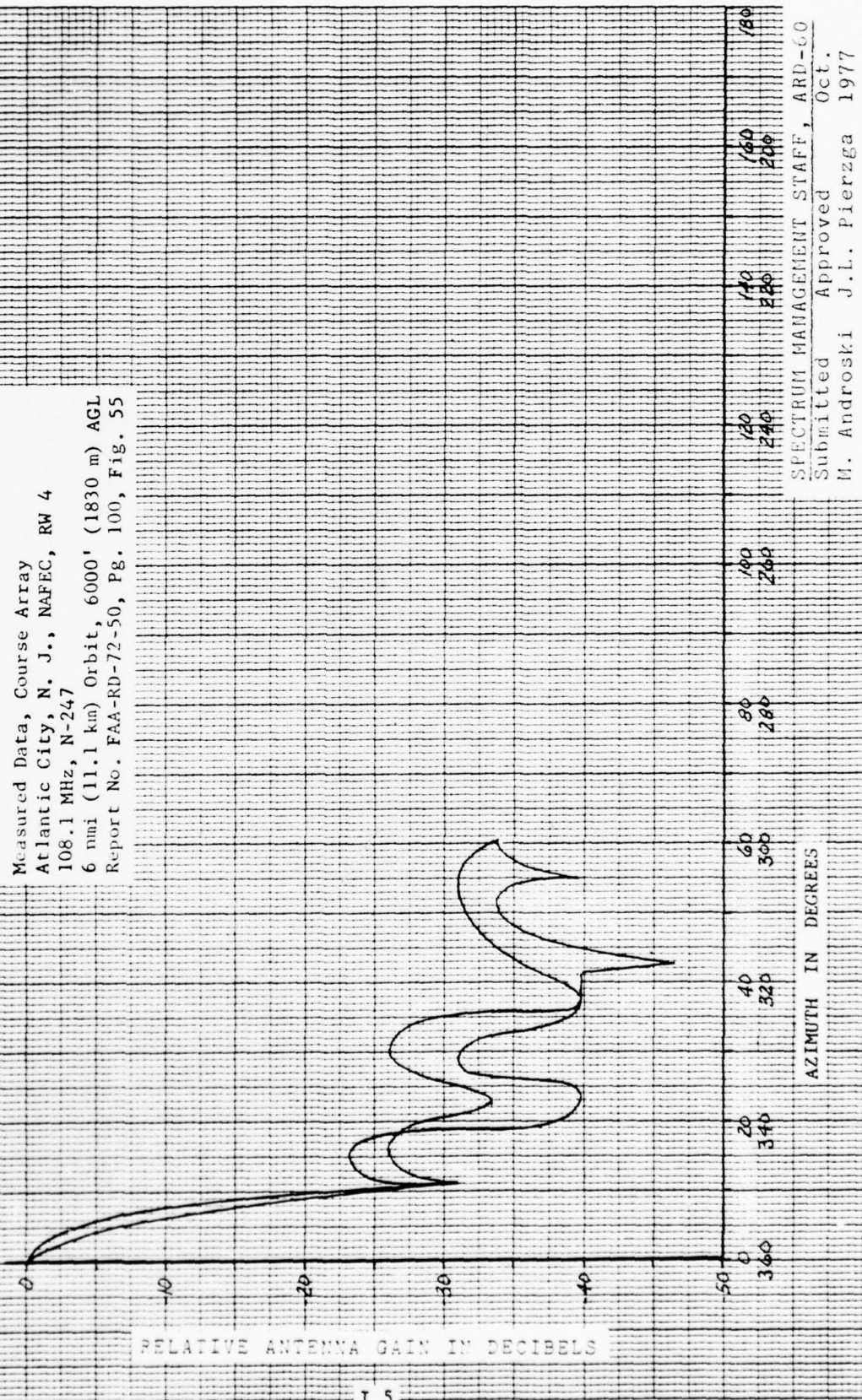


FIGURE I 4

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted Approved Oct.
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APPENDIX J

A.M.C. AND T.I. TRAVELING WAVE ANTENNAS

This array was originally designed by Alford Manufacturing Company. Texas Instruments brought the rights and made some modifications to it. Of particular interest are the modifications to the distribution panel. Each element of the arrays is identical (Alford Type 4770). The element is an end-fire traveling wave antenna. The designations used by Alford for various arrays have not been used in FAA specification and T.I. has continued to use Alford's designations. They are as follows:

i. Type C 6-1 Six Element Clearance Array

This array is used in the two frequency capture effect Category II systems as the clearance array.

ii. Type Zero Eight Element Array

This array can be used alone in single frequency, Category I systems, or as the clearance array in two frequency, capture effect, Category II or III systems.

iii. Type 1A Fourteen Element Self-Clearing Array

This array is designated for use alone in single frequency, Category II systems.

iv. Type 1B Fourteen Element Course Array

This array is used as the course array in two frequency, capture effect, Category II systems. The difference between Type 1B and Type 1A lies in the relative magnitude of powers applied to the various antenna elements. Normally, this array is used with a six element clearance array.

v. Type 2 Twenty-two Element Course Array

This array is used as the course array in two frequency, capture effect, Category II or III systems. Normally, this array is used with an eight element clearance array.

T.I. has used a computer model to determine antenna patterns for each of the five Alford arrays mentioned above (Reference 22). Discussion with the author of this document and other T.I. personnel has indicated that there are no differences between the theoretical patterns of the T.I. and the Alford system and that there should be little, if any, differences in the measured data. These conclusions are partially based on results of testing of the two systems at NAFEC (Reference 24). Analysis of the data from this source shows that the two antennas are very similar, although the Alford array had a smaller front to back ratio. This was due to the fact that "no particular effort was made to match the A.M.C. elements at the monitor ends."

A. T.I. Traveling Wave Antenna (14/6)

This is a two frequency, capture effect system, with 9.5 kHz between frequencies. The course array (Type 1B) consists of 14 traveling wave antenna elements. The clearance array (Type C 6-1) has six of the same type of elements. Theoretical data (References 9 and 22) and measured data (Reference 24) were obtained from the manufacturer. Theoretical data was also obtained from a Wilcox Instruction Book (Reference 11) where the A.M.C. and L.P.D. were compared. With few exceptions, measured and theoretical data, from various sources, have shown good comparison. The exceptions might be noted as follows:

- i. With the assumption that the T.I. and A.M.C. systems are essentially identical, the measured data (Reference 24) on the A.M.C. 14 element, Type 1B array, has "back course" radiation in excess of both theoretical data and other measured data. As mentioned before, this was due to the fact that "no particular effort was made to match the A.M.C. elements at the monitor ends."
- ii. An unnumbered drawing has been received from T.I. (Figure J 11) showing a composite radiation pattern for the course and clearance arrays. This pattern has been compared with measured data taken in January 1976. From the front course out to 45 degrees, the data shows good agreement. From 45 to 90 degrees, the theoretical data shows the relative power of the antenna as much smaller than the measured data. Theoretical data was not given beyond 90 degrees.

- iii. Theoretical data obtained from the T.I. Instruction Book (Reference 9) is limited to within 30 degrees of the front course. The pattern given for the composite of course and clearance arrays agrees well with the measured data taken in January 1976. The individual patterns given for the course and the clearance arrays are much sharper than measured data.

Unlike the A.P.C. traveling wave and the Wilcox L.P.D., no manufacturers statements have been found claiming that any of the traveling wave antennas meets any FAA specification concerning antenna radiation patterns. It is assumed that this particular combination (Type 1B, 14 Element Course Array, and Type C 6-1, 6 Element Clearance Array) should be required to meet the requirements of specification FAA-E-2554 (Type I). Comparison of the specification and FAA measured data (Figure J 18, taken at an elevation angle of approximately five degrees) raises doubts concerning whether the required front to back ratio can be met. In a similar situation with the Wilcox L.P.D. antenna, manufacturer's data (taken at an elevation angle of zero degrees) show that the requirement is met at that elevation angle. Similar data have not been found for the T.I. Traveling Wave. With this exception, the measured data compared well with the specification's requirements for antenna patterns.

B. T.I. Wide Aperature Traveling Wave Antenna (22/8)

This is a two frequency, capture effect system, with 9.5 kHz between frequencies. The course array (Type II) consists of 22 traveling wave antenna elements. The clearance array (Type Zero) has eight of the same type of traveling wave elements.

Theoretical data has been obtained from the manufacturer on each array (Reference 22) but no composite patterns are available. As for measured data, no FAA data is presently available for either of the two arrays or their composite. As a general rule, manufacturer's "typical" patterns are assumed to be theoretical.

Although this system has not been installed, it is assumed that specification FAA-E-2554 (Type II) would be applicable to any installations that are made in the future.

C. T.I. Narrow Aperature Traveling Wave Antenna (14)

This is a two frequency, capture effect system, with 9.5 kHz between frequencies. Both course and clearance are fed into the 14 element array. This system is presently in the development stage. The antenna radiation pattern is expected to be quite similar to the system which feeds course and clearance information into a separate 14 element, Type 1B, course array and a six element, Type C 6-1, clearance array. It is assumed that specification FAA-E-2554 (Type I) would be applicable.

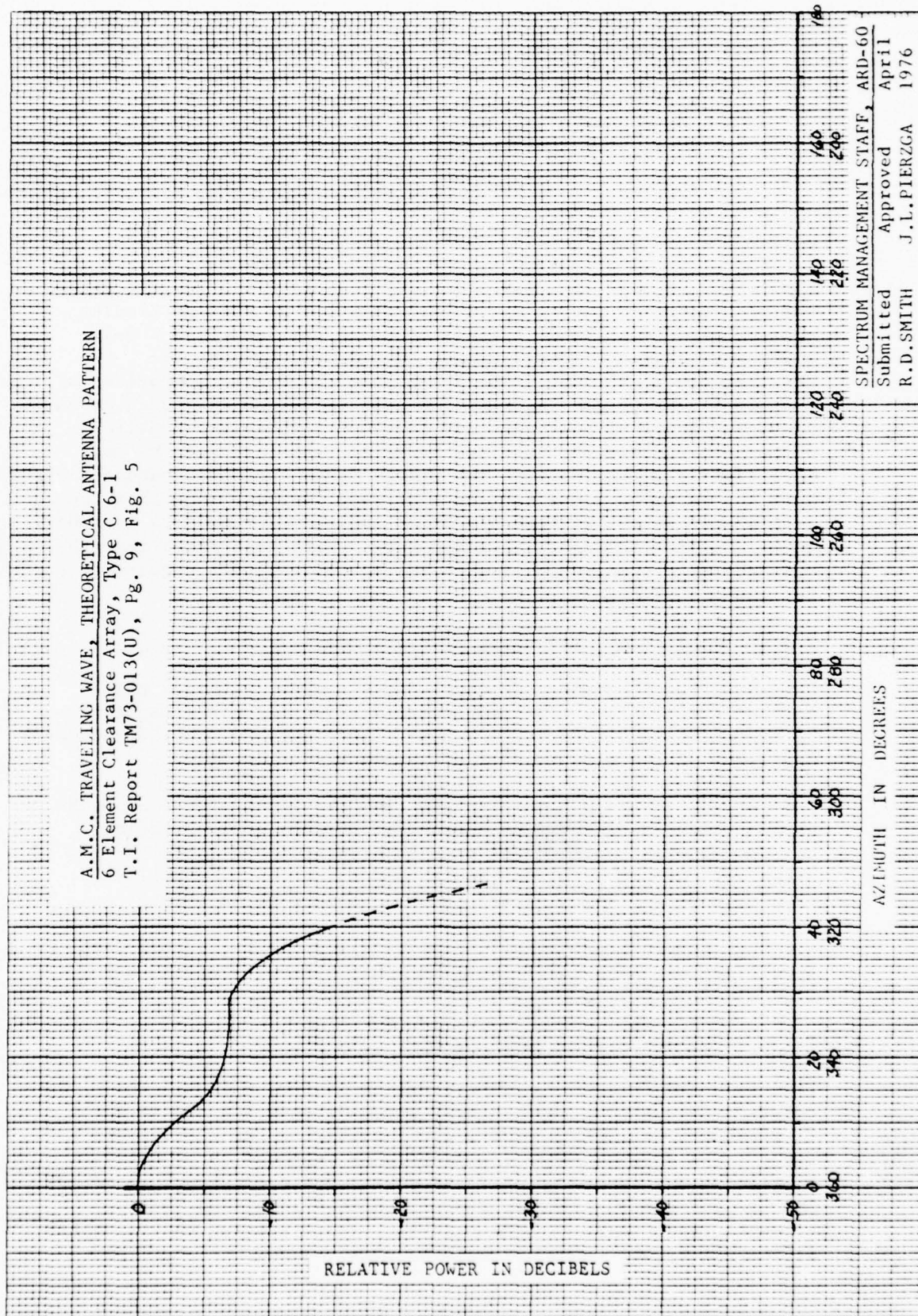


FIGURE J 1

A.M.C. TRAVELING WAVE, THEORETICAL ANTENNA PATTERN
 8 Element Clearance Array, Type 0
 T.I. Report TM73-013(U), Pg. 16, Fig. 10

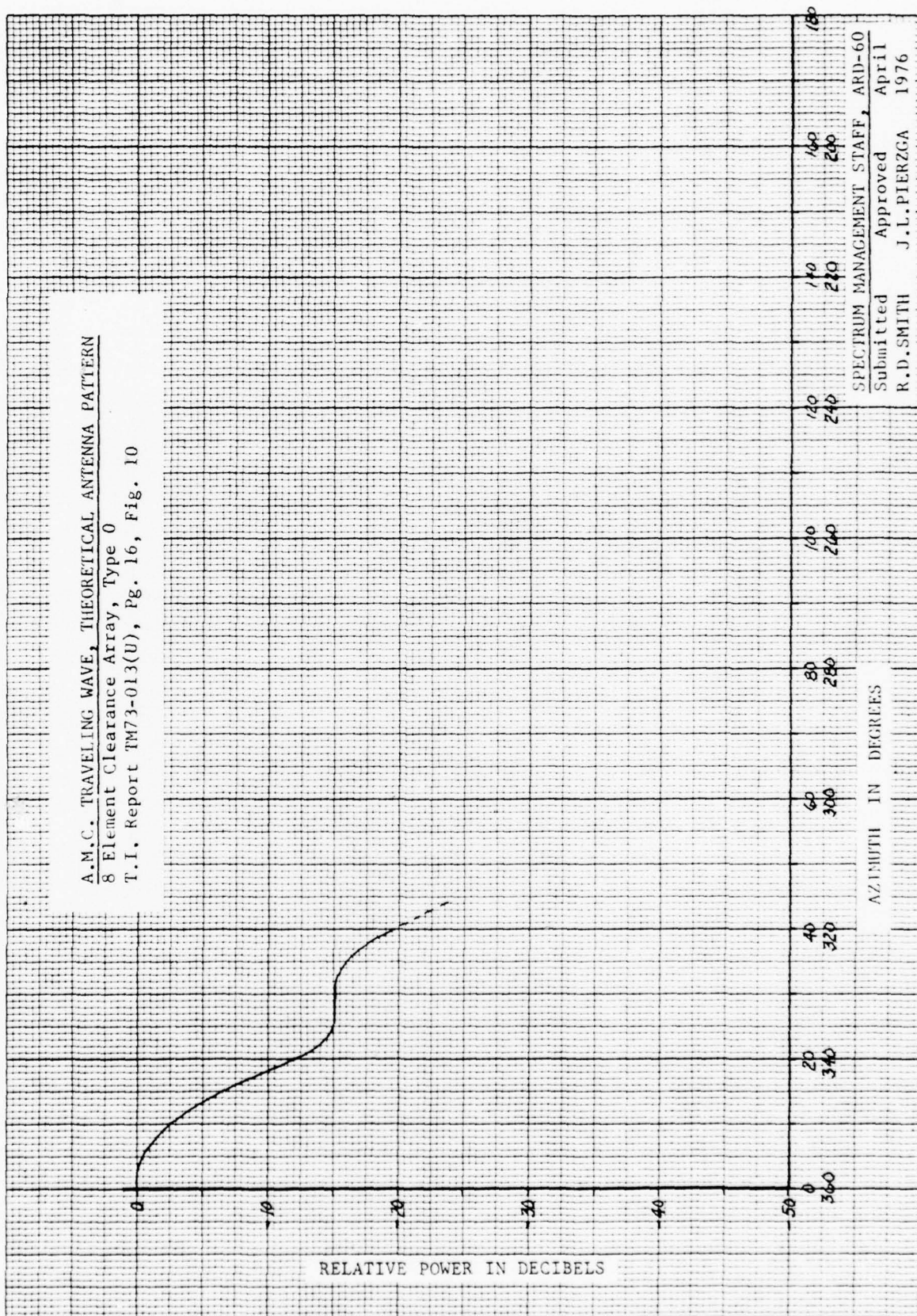


FIGURE J 2

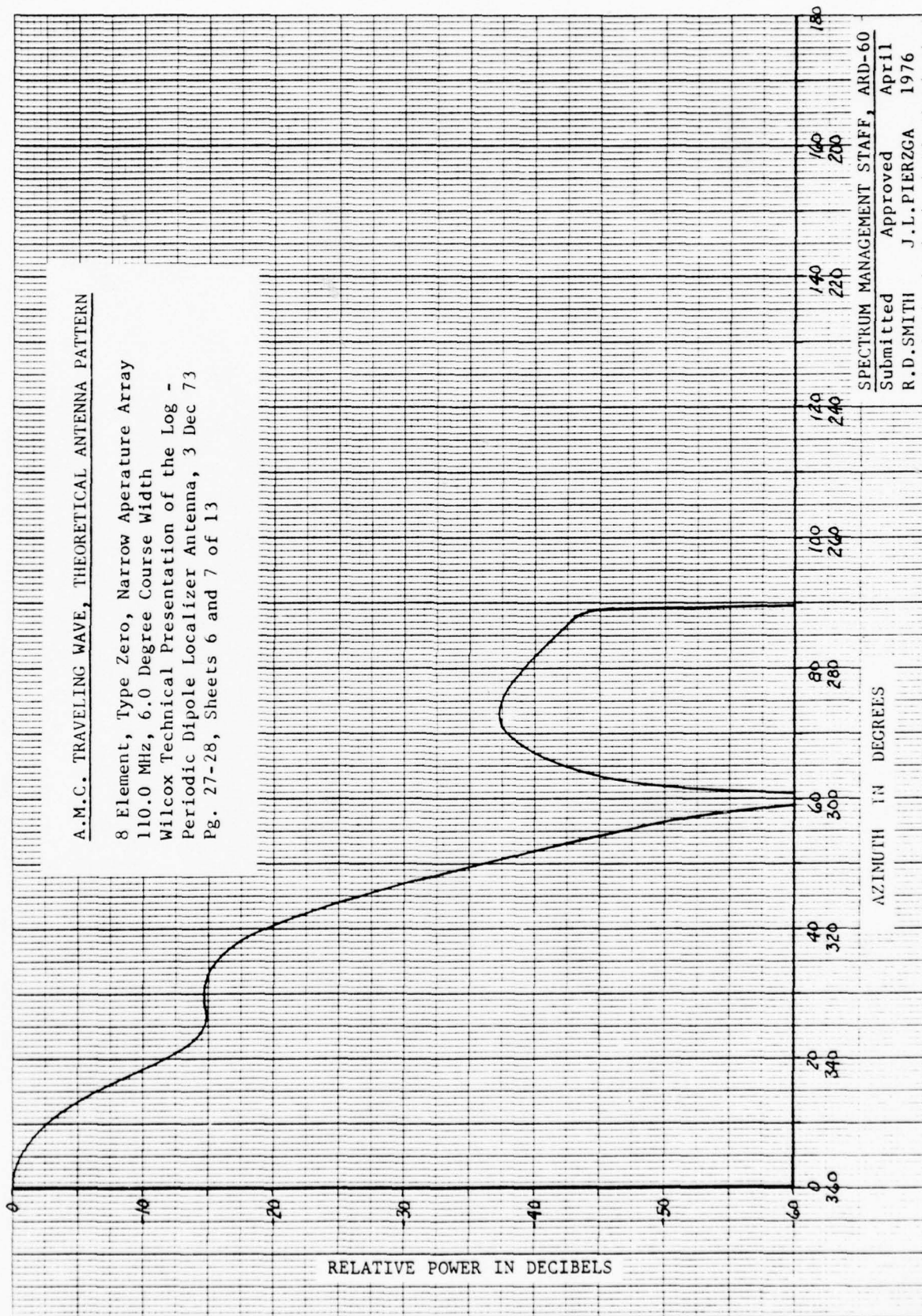
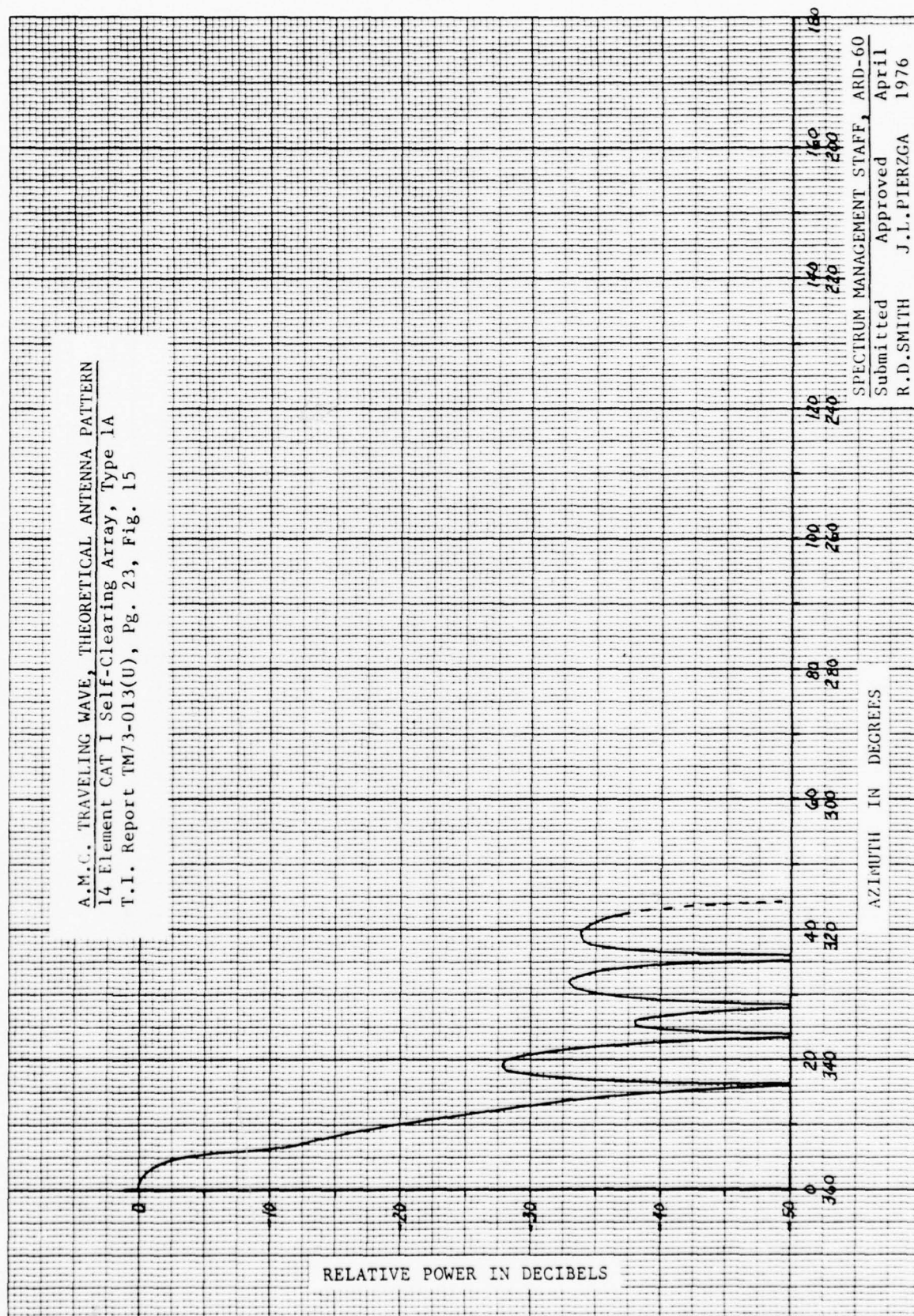


FIGURE J 3

A.M.C. TRAVELING WAVE, THEORETICAL ANTENNA PATTERN
 14 Element CAT I Self-Clearing Array, Type 1A
 T.I. Report TM73-013(U), Pg. 23, Fig. 15



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 April 1976

FIGURE J 4

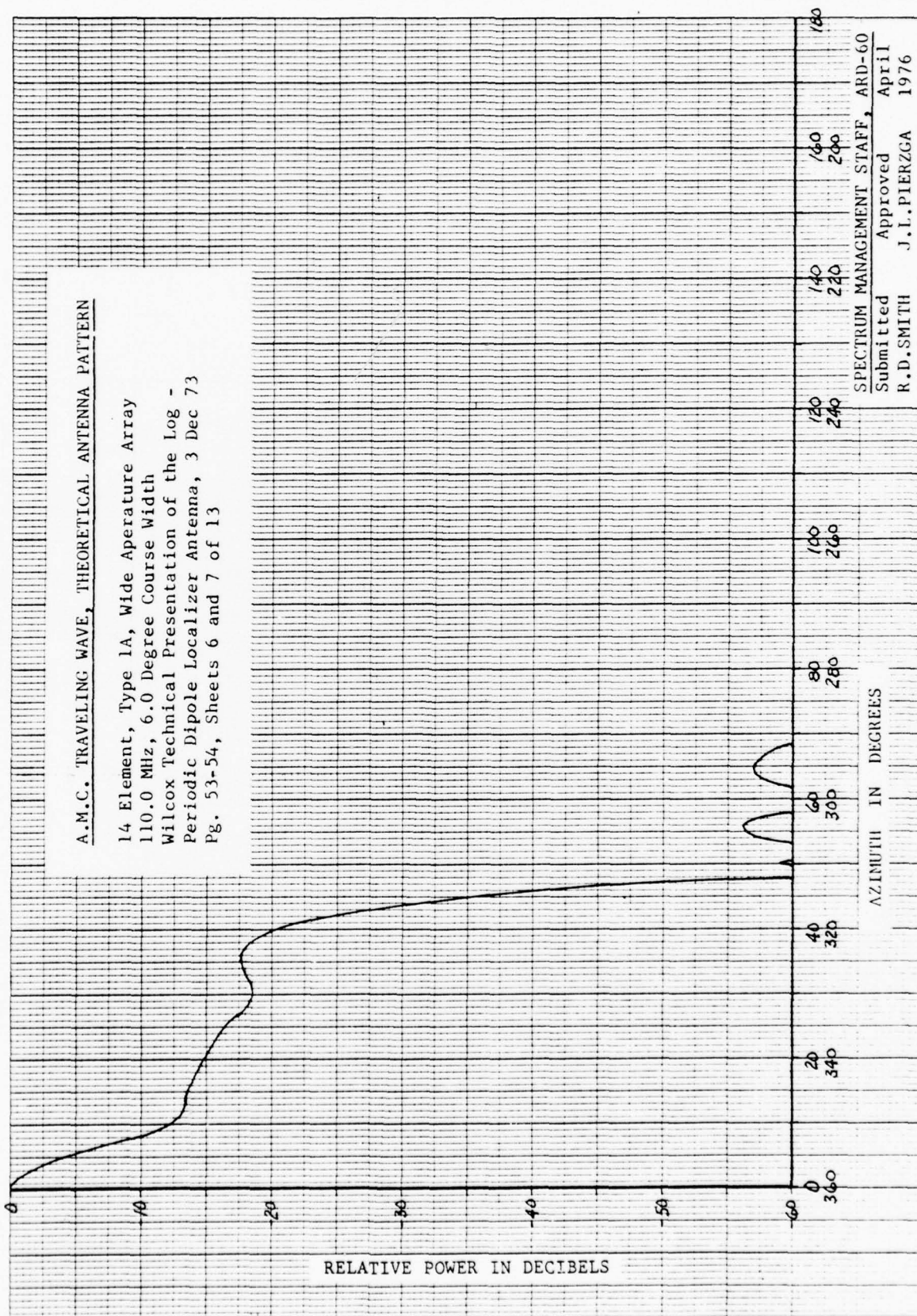


FIGURE J 5

A.M.C. TRAVELING WAVE, THEORETICAL ANTENNA PATTERN
 14 Element CAT II Course Array, Type 1B
 T.I. Report TM73-013(U), Pg. 30, Fig. 30

RELATIVE POWER IN DECIBELS

AZIMUTH IN DEGREES

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FIGURE J 6

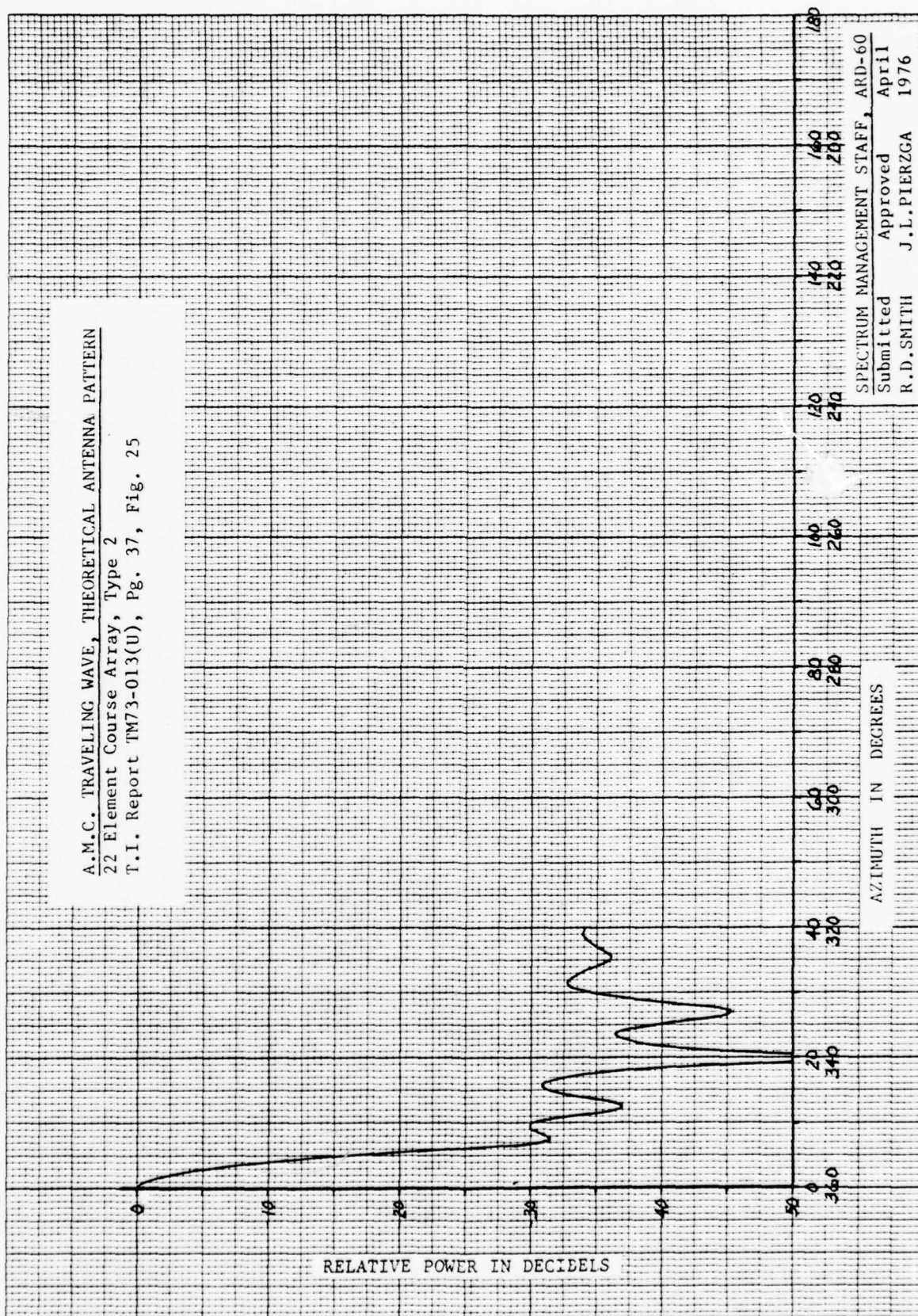
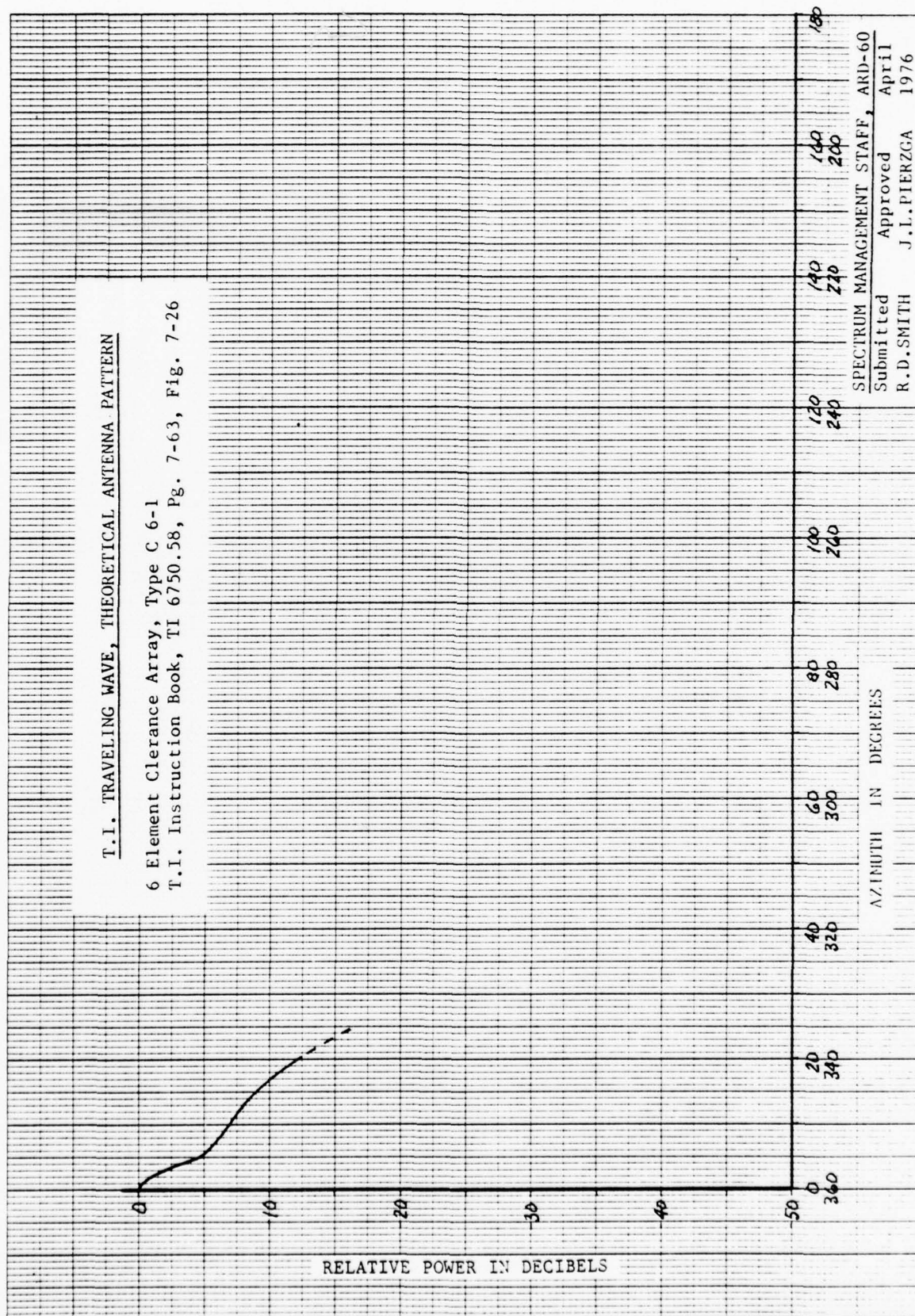


FIGURE J 7

T.I. TRAVELING WAVE, THEORETICAL ANTENNA PATTERN

6 Element Clearance Array, Type C 6-1
T.I. Instruction Book, TI 6750.58, Pg. 7-63, Fig. 7-26



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April 1976

FIGURE J 8

T.I. TRAVELING WAVE, THEORETICAL ANTENNA PATTERN

14 Element Course Array, Type 1B
T.I. Instruction Book, TI 6750.58, Pg. 7-60, Fig. 7-23

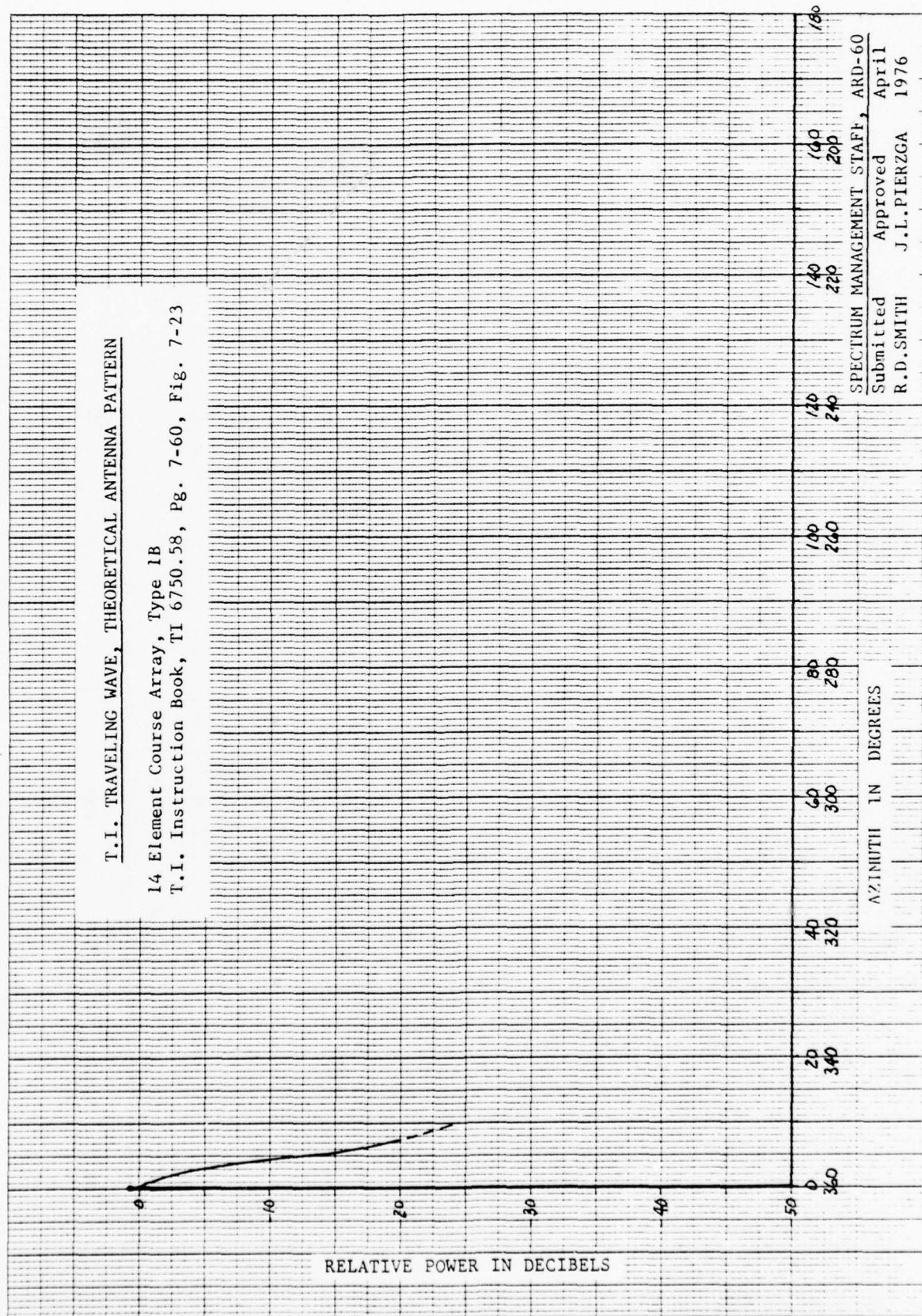
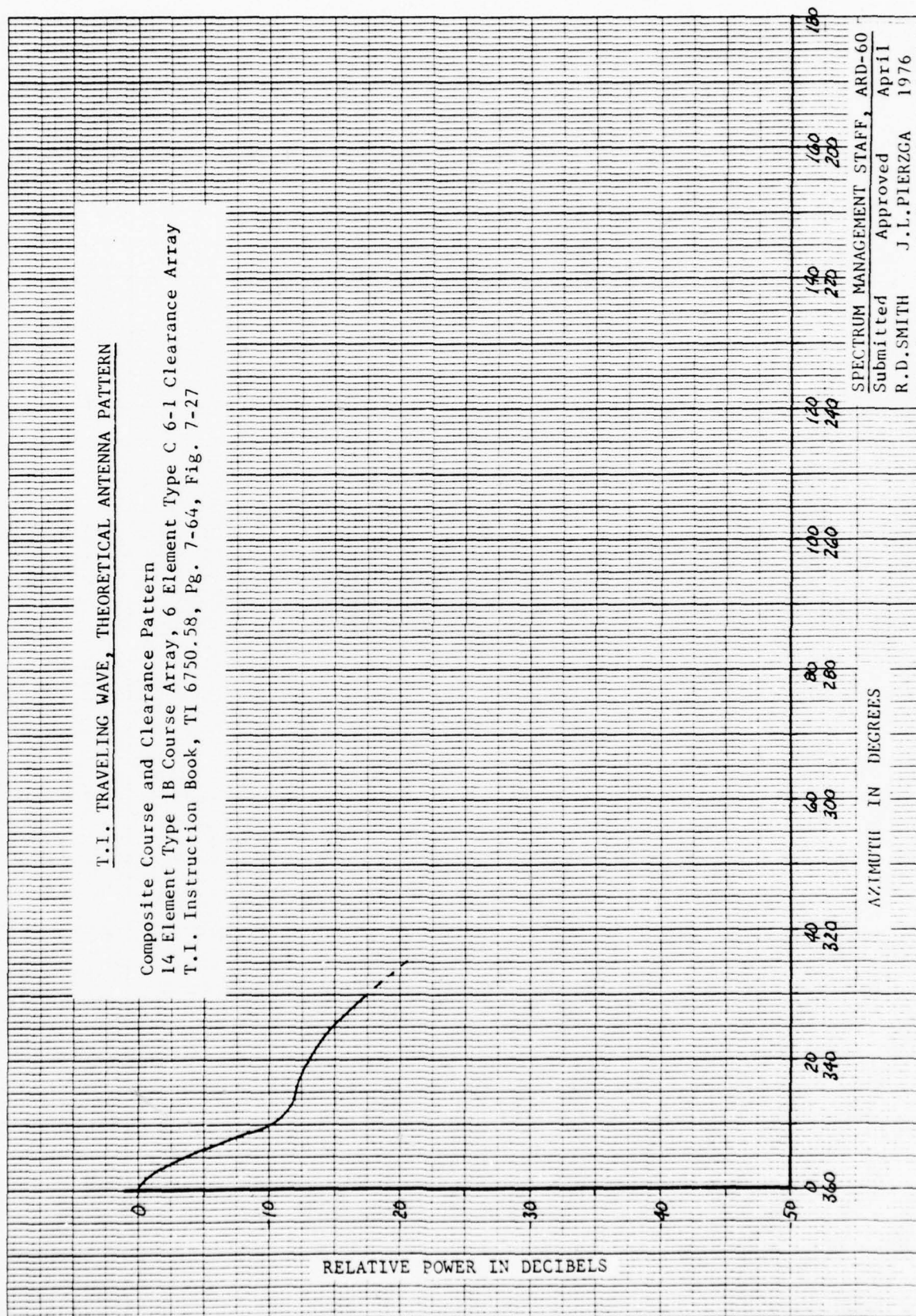


FIGURE J 9

T.I. TRAVELING WAVE, THEORETICAL ANTENNA PATTERN

Composite Course and Clearance Pattern
 14 Element Type 1B Course Array, 6 Element Type C 6-1 Clearance Array
 T.I. Instruction Book, TI 6750.58, Pg. 7-64, Fig. 7-27



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 April 1976

FIGURE J 10

T.I. TRAVELING WAVE, THEORETICAL ANTENNA PATTERN
 14 Course Elements, 6 Clearance Elements
 Unnumbered Drawing Obtained From Manufacturer

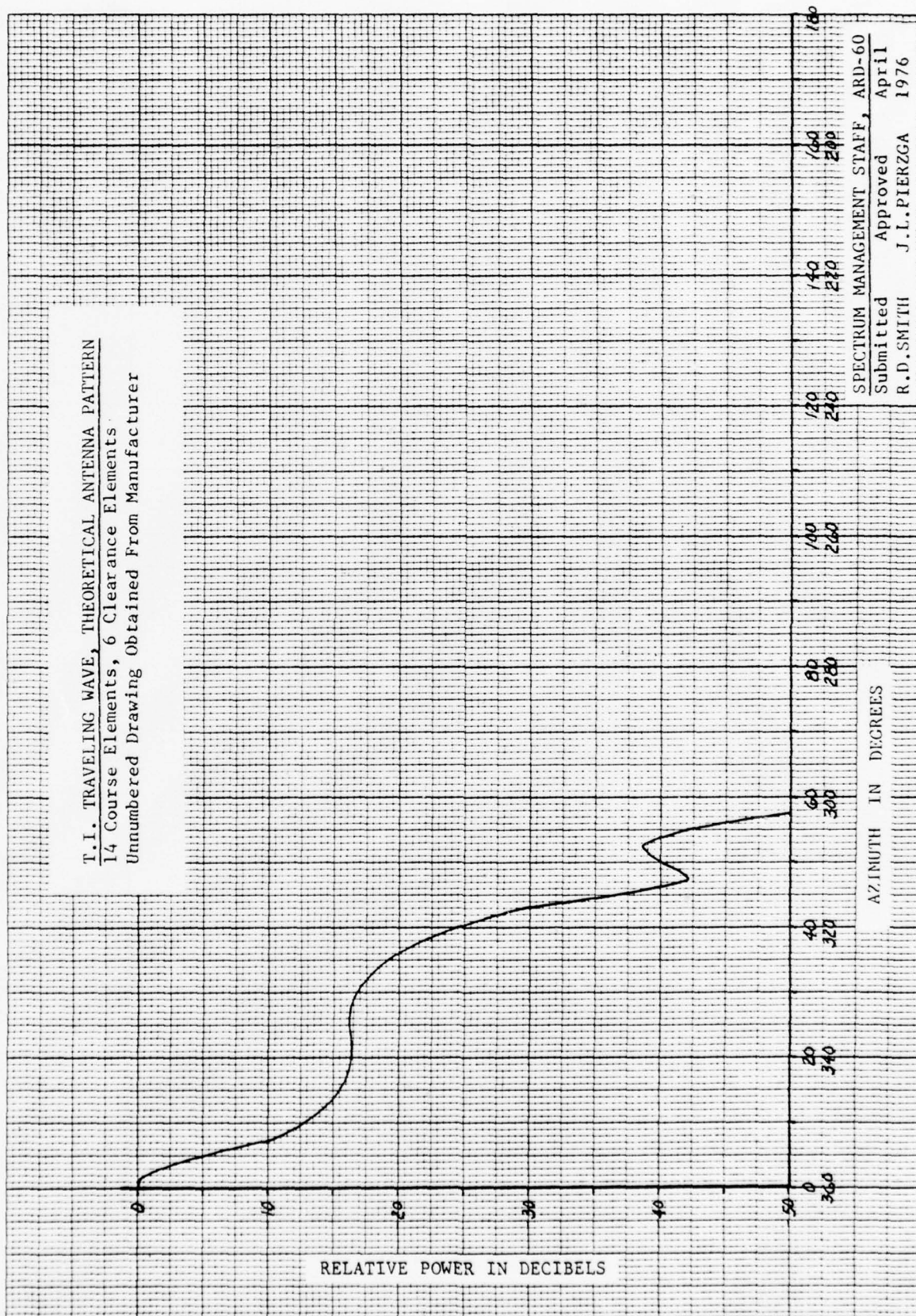


FIGURE J 11

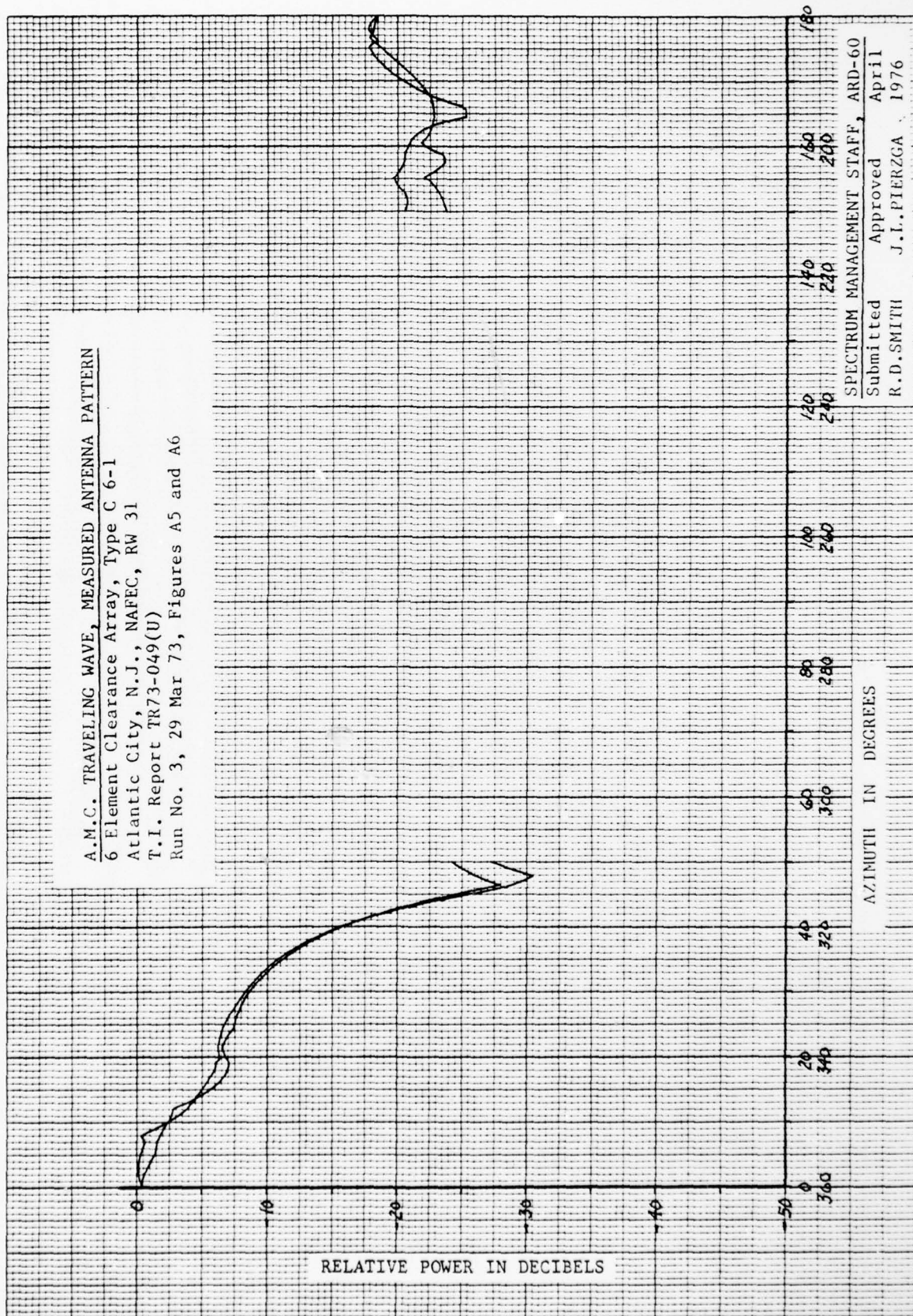


FIGURE J 12

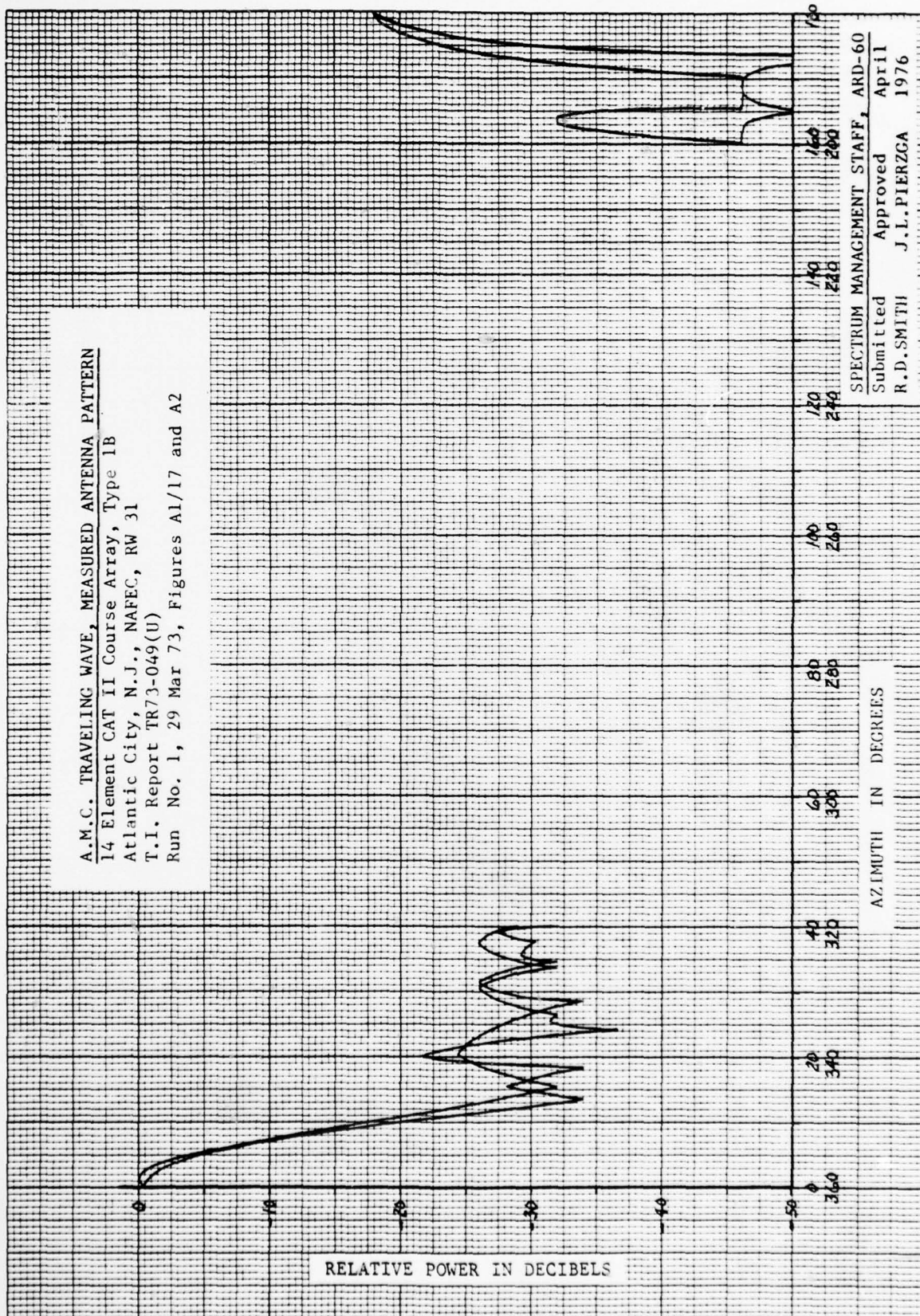


FIGURE J 13

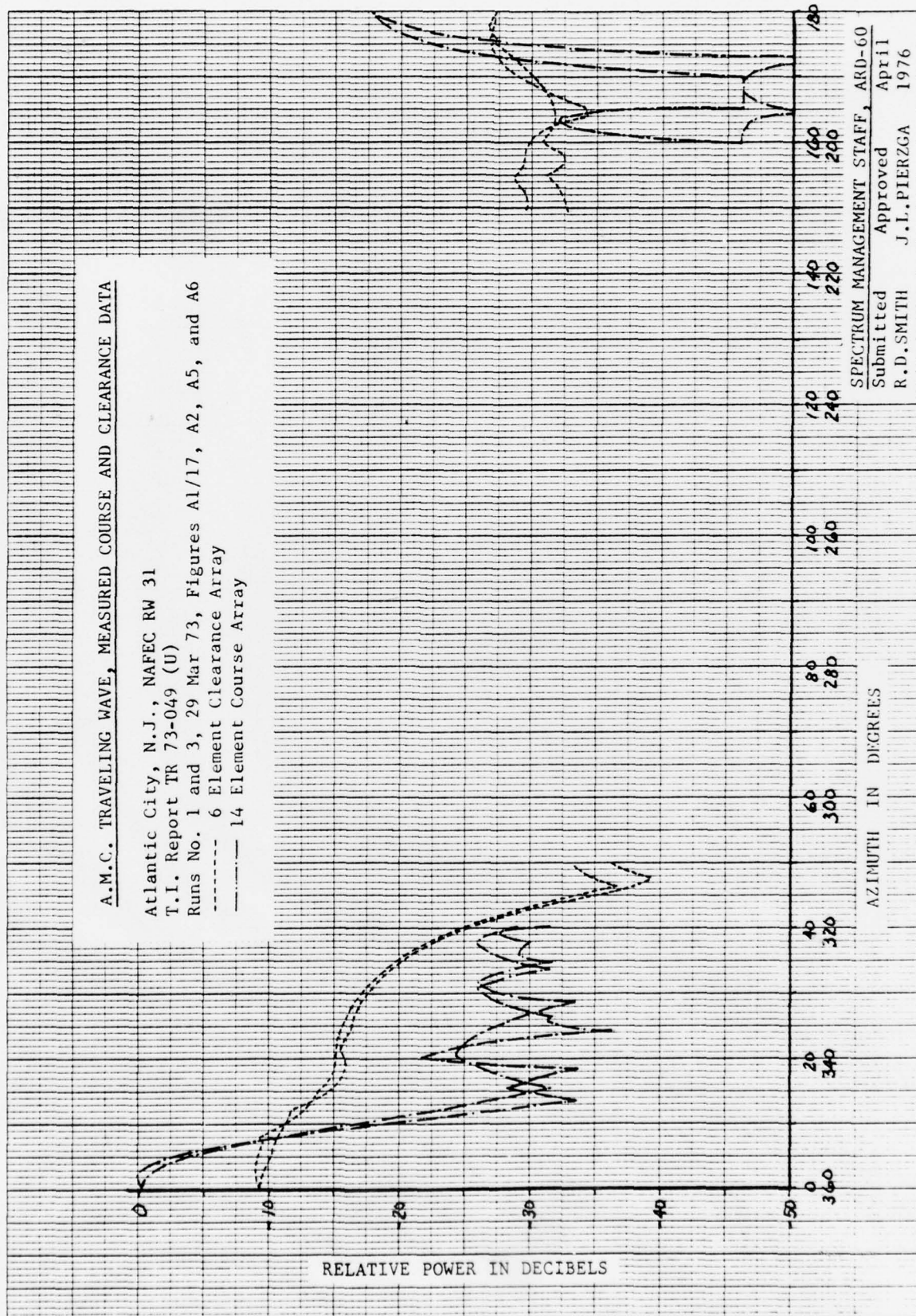


FIGURE J 14

T.I. TRAVELING WAVE, MEASURED ANTENNA PATTERN
 6 Element Clearance Array
 Atlantic City, N.J., NAFEC, RW 31
 T.I. Report TR73-049(U)
 Run No. 3, 14 April 73, Figures B5 and B6

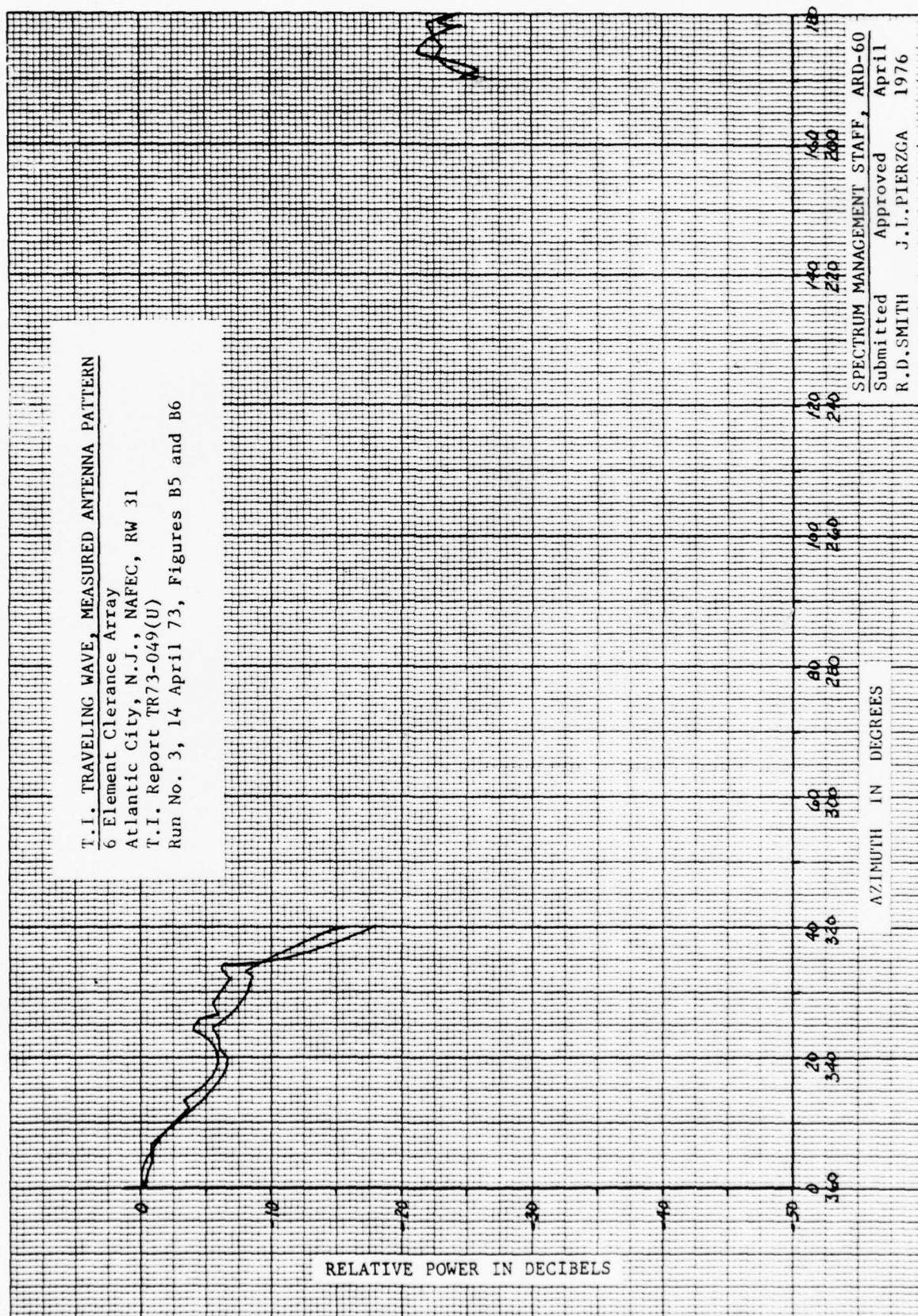


FIGURE J 15

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T.I. TRAVELING WAVE, MEASURED ANTENNA PATTERN
 14 Element CAT II Course Array
 Atlantic City, N.J., NAFEC, RW 31
 T.I. Report TR73-049(U)
 Run No.1, 14 Apr 73, Figures B1/11 and B2

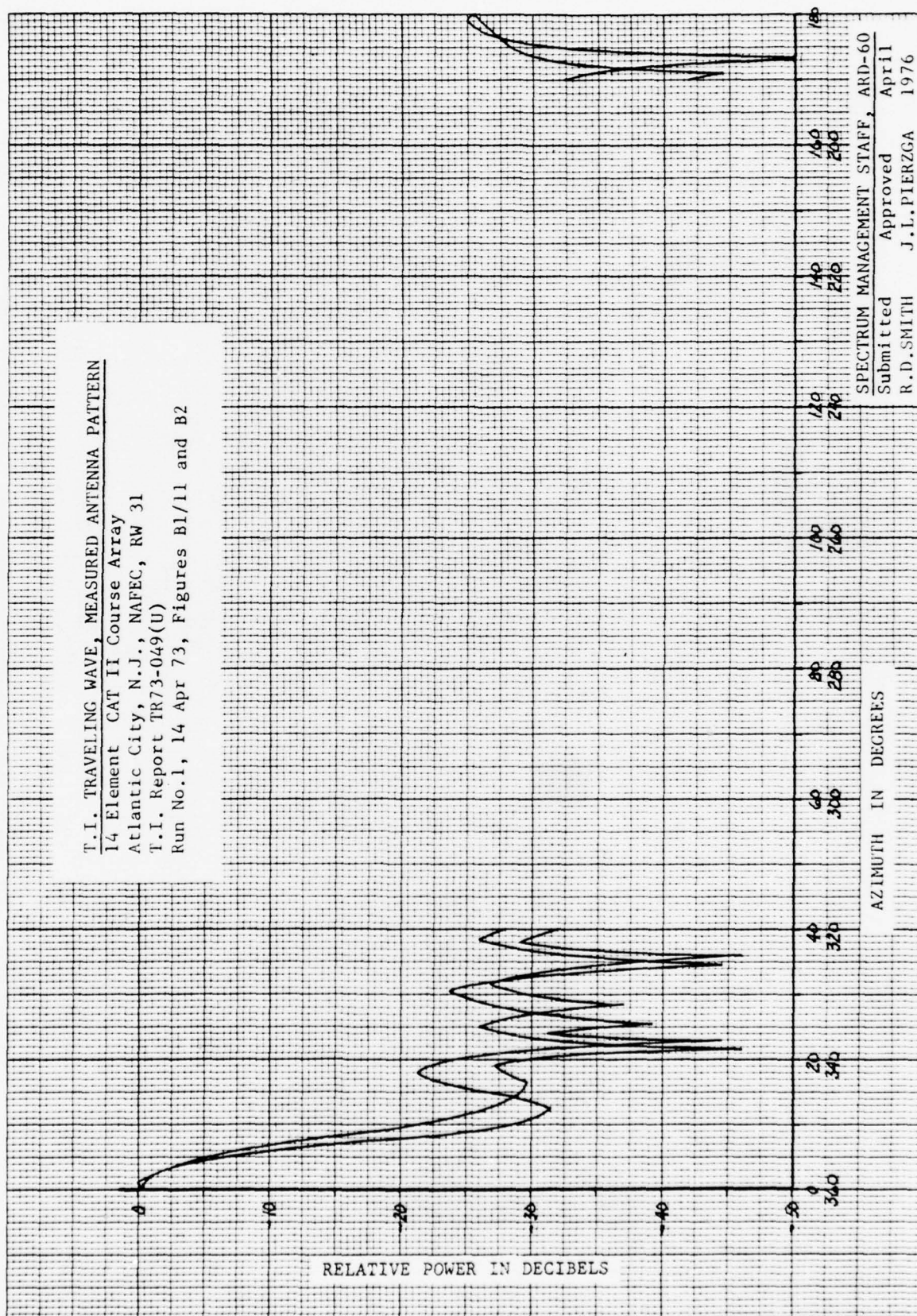


FIGURE J 16

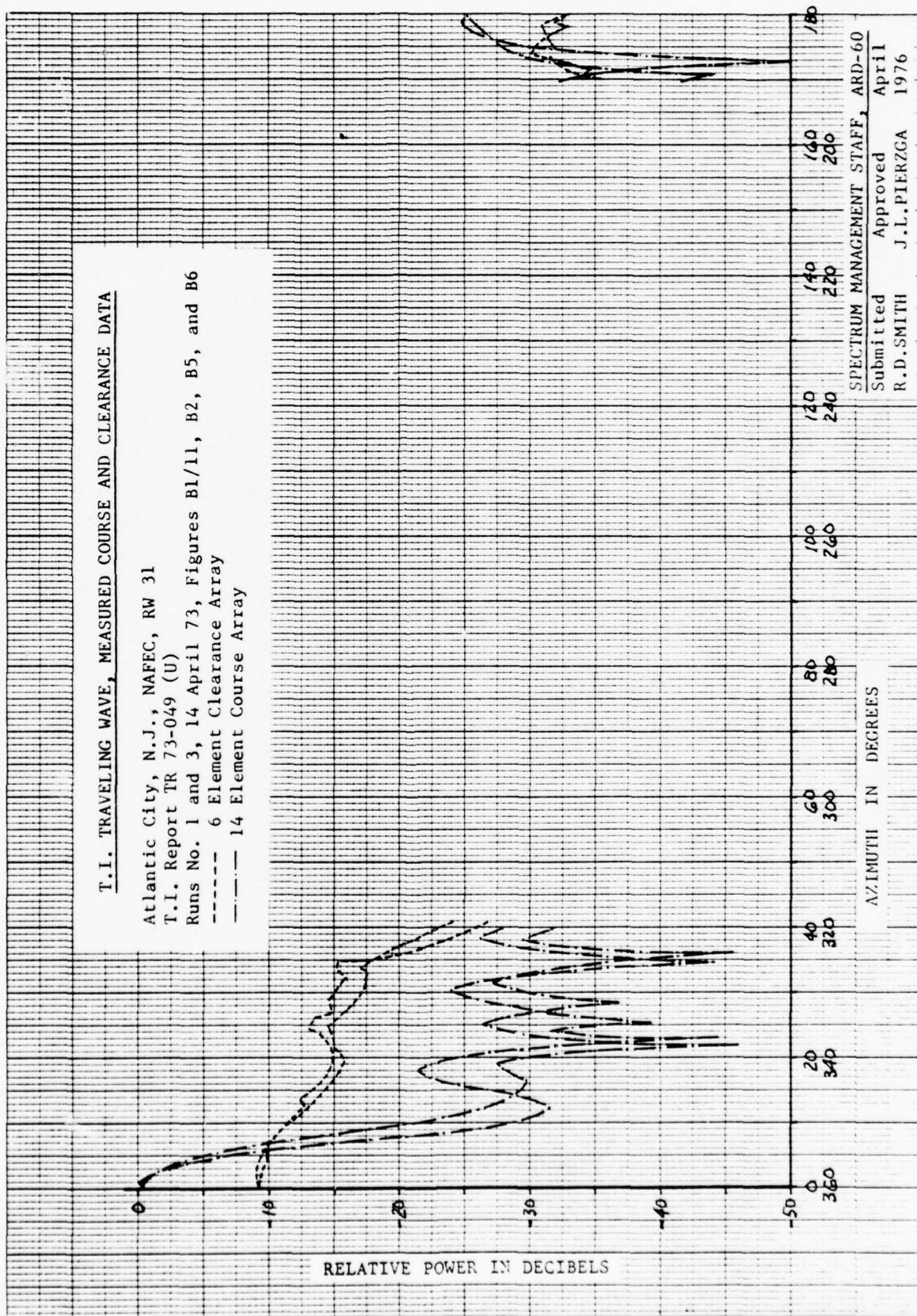


FIGURE J 17

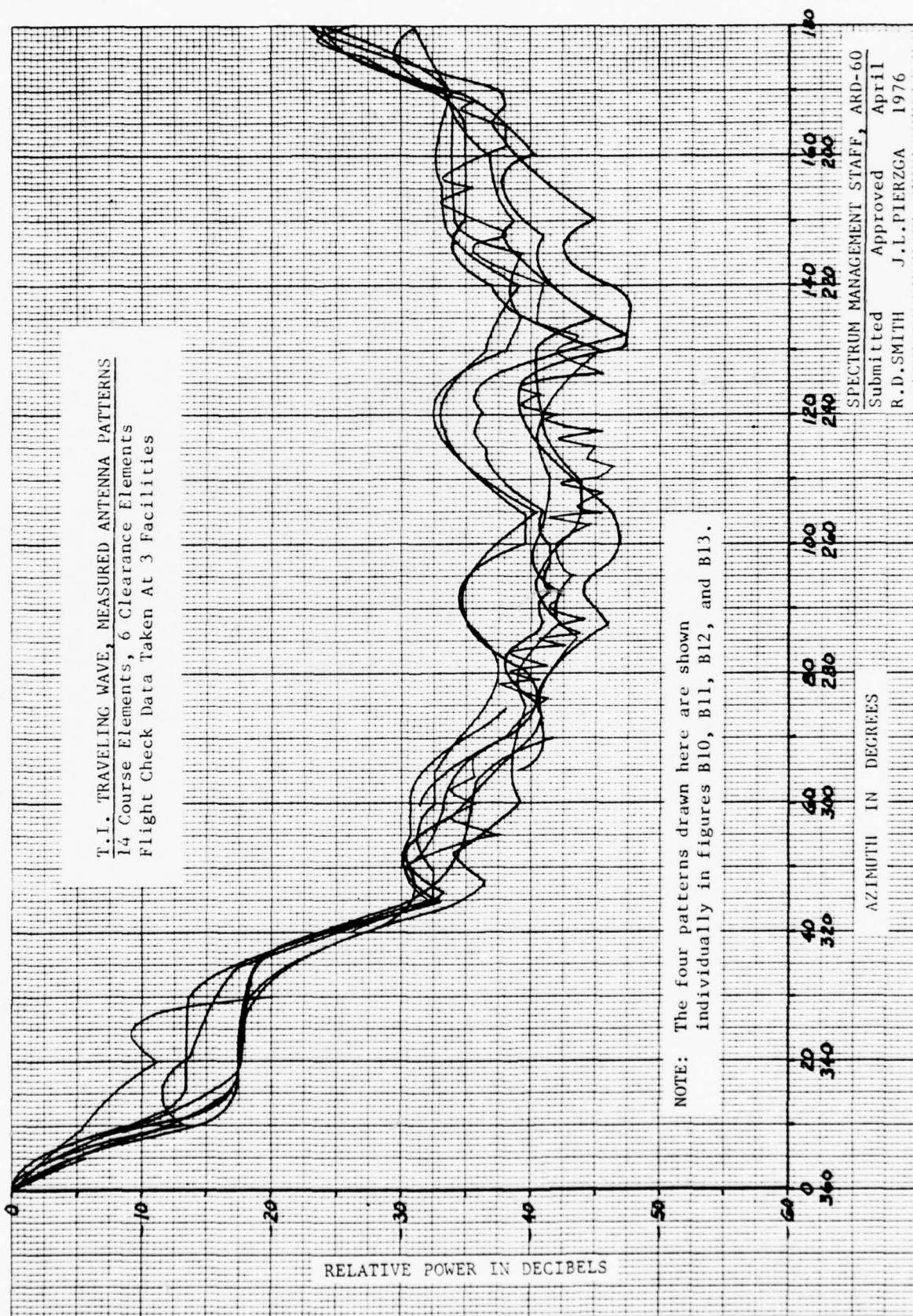


FIGURE J 18

APPENDIX K

A.P.C. TRAVELING WAVE ANTENNA

A. A.P.C. Traveling Wave Antenna (Type I, 8 Elements) FA-9320

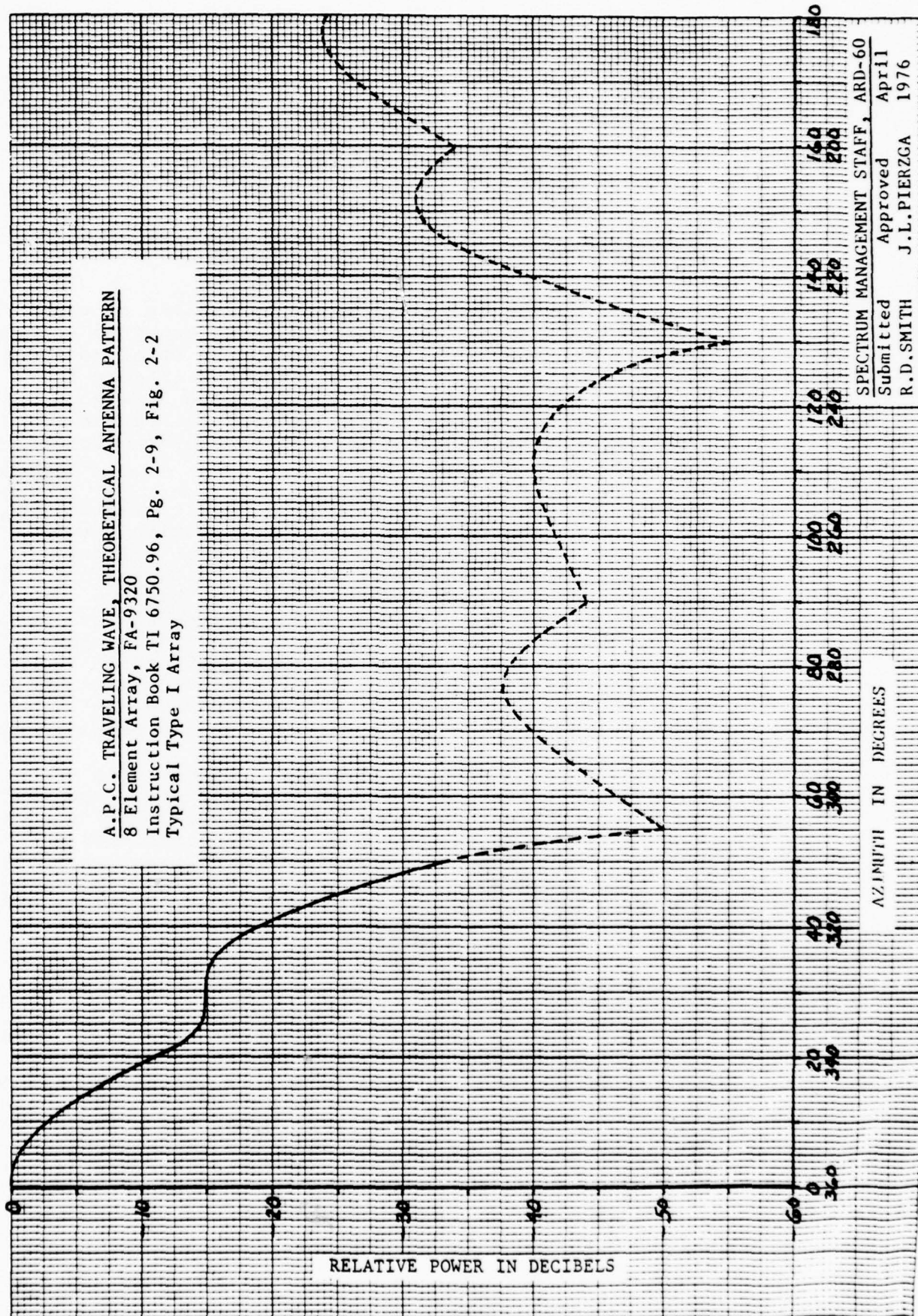
This is a single frequency array consisting of eight folded dipole elements supported by an aluminum channel. A theoretical pattern for the array was obtained from the manufacturer's instruction handbook (Figure K1). Empirical data and the theoretical curve show good agreement on the front course but some differences appear when comparing the back course information of the respective arrays.

The manufacturer's instruction handbook claims that the array is manufactured in accordance with Specification FAA-E-2554 (Type I). Both theoretical data and measured data show good agreement with the specification's front course requirements. Neither the theoretical nor the measured data (Figure K2) compared favorably with the specification's requirement that the back course be down 26 dB. The instruction book (Reference 4) claims only a 22 dB front to back ratio, so it would appear that the manufacturer is admitting that the equipment does not meet the 26 dB requirement.

In somewhat similar circumstances, FAA measured data (taken at an elevation angle of five degrees) show that the Wilcox LPD antenna does not meet the 26 dB requirement for front to back ratio. Manufacturer's data (taken at an elevation angle of zero degrees) show that this requirement is met with several dB to spare. Data have not been found to demonstrate if similar statements can be made for the A.P.C. antenna.

B. A.P.C. Traveling Wave Antenna (Type II, 14 Elements) FA-9325

This is a single frequency array consisting of 14 folded dipole elements supported by an aluminum channel. No facilities of this type are currently installed, although it is understood that a small number of them have been bought. No theoretical patterns have been obtained for this antenna. It is assumed that the antenna pattern specification which applies is FAA-E-2554 (Type II).



A.P.C. TRAVELING WAVE, MEASURED ANTENNA PATTERNS
 8 Element Arrays, FA-9320
 Flight Check Data Taken At 3 Facilities

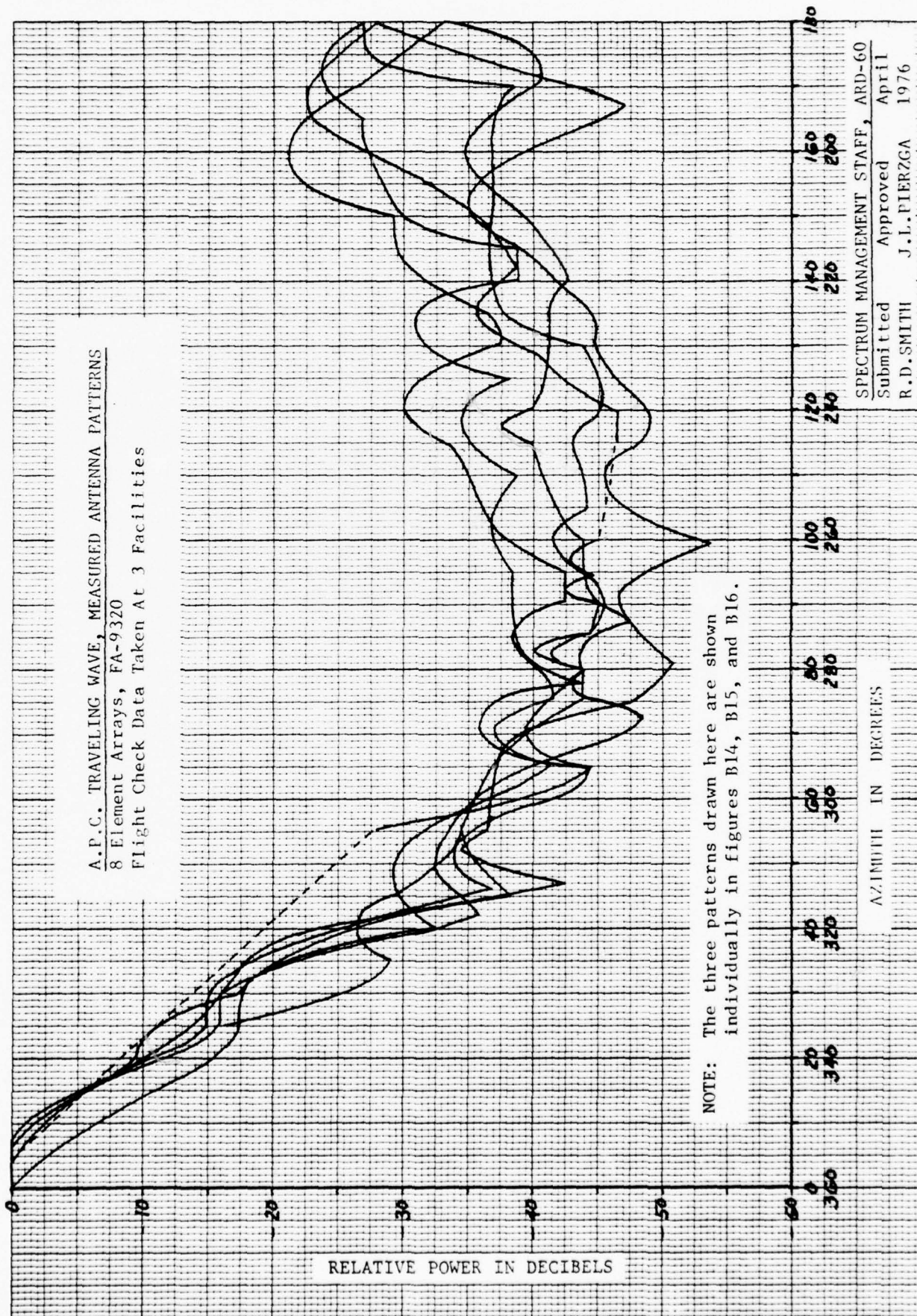


FIGURE K 2

APPENDIX L

FIFTEEN ELEMENT V-RING ANTENNA

The standard 15 element V-Ring is a single frequency array of "V-Ring" elements. This array results in a higher percentage of energy being radiated on course than that of the 8-Loop array. As the V-Ring began to replace the 8-Loop as the standard, it was decided that the coverage claimed for the system should be limited to ± 35 degrees off the course. This was a direct result of the directivity of the antenna which made it difficult to provide 360 degree clearance without unreasonably high power. Lower power off course had also made it difficult to provide frequency protection beyond 35 degrees.

Information concerning the early development of the V-Ring has been obtained from an unpublished document (Reference 25). A number of arrays were considered, two of which were perfected by Scanwell Laboratories in 1963. Although information is sketchy, it appears that the Type I (Figure L2) was later dropped and that the Type III (Figure L2) has been manufactured in quantity.

Theoretical pattern (Figure L2) compares well with measured data taken at two Dallas facilities (Figures L4 through L17). The measured data is quite interesting in that it is the most extensive measured data available on one antenna type. Data taken at six altitudes, for each facility, shows the results of terrain as a function of altitude.

Specification FAA-E-2247b contains limitations on the radiation pattern of the standard, 15 element, V-Ring antenna. The theoretical, Type III pattern, fell within these limitations. Although the measured data showed fair comparison with the specification, some discrepancies were seen. Measured data exceeded the upper limitation on the front course at some altitudes. It also went below the lower limit on the back course at some altitudes.

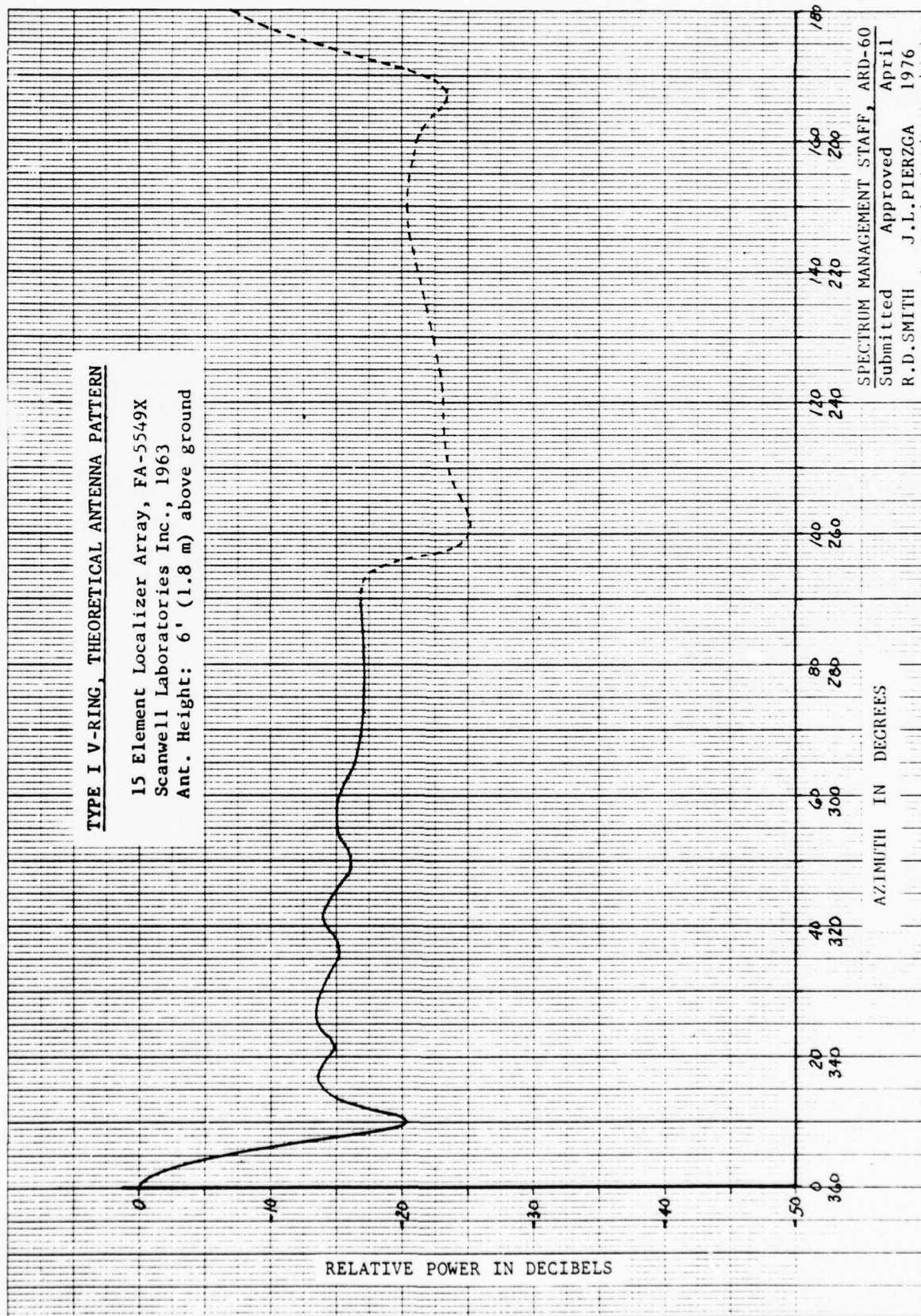
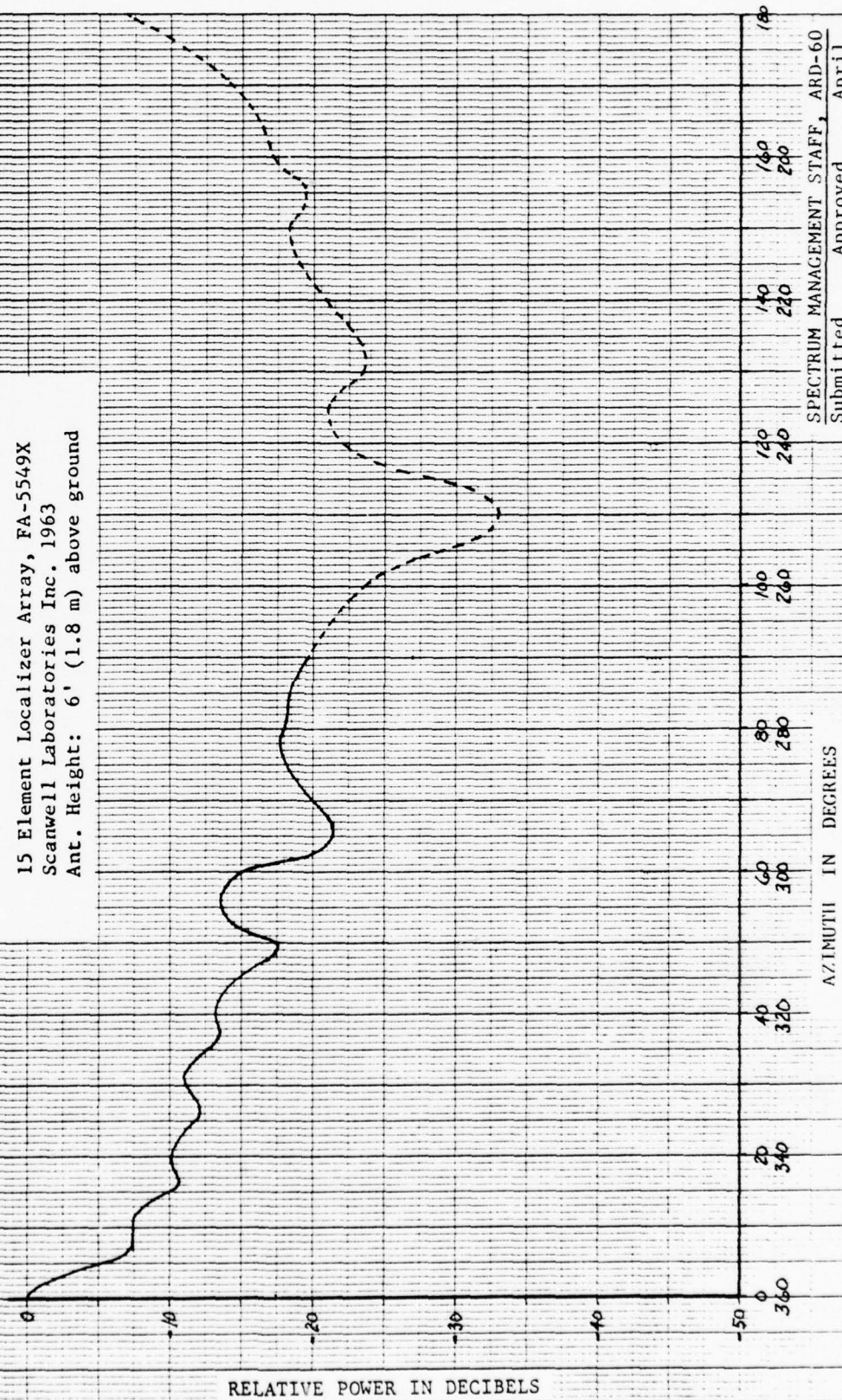


FIGURE L 1

TYPE III V-RING, THEORETICAL ANTENNA PATTERN

15 Element Localizer Array, FA-5549X
Scanwell Laboratories Inc. 1963
Ant. Height: 6' (1.8 m) above ground



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Approved J.L. PIERZGA
April 1976

FIGURE L 2

STANDARD V-RING, MEASURED ANTENNA PATTERNS

Fifteen Element Array
Flight Data Taken At 2 Facilities

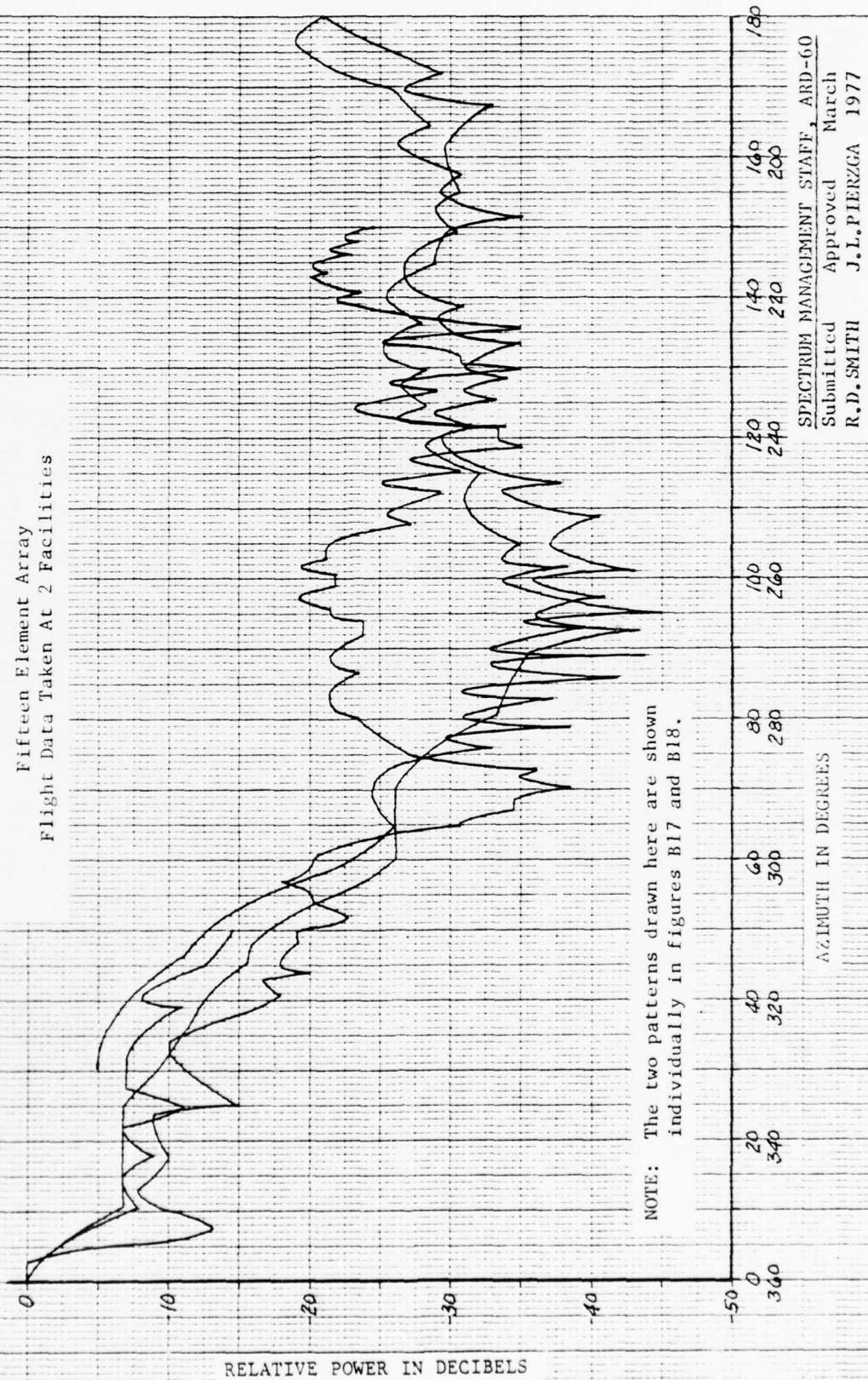
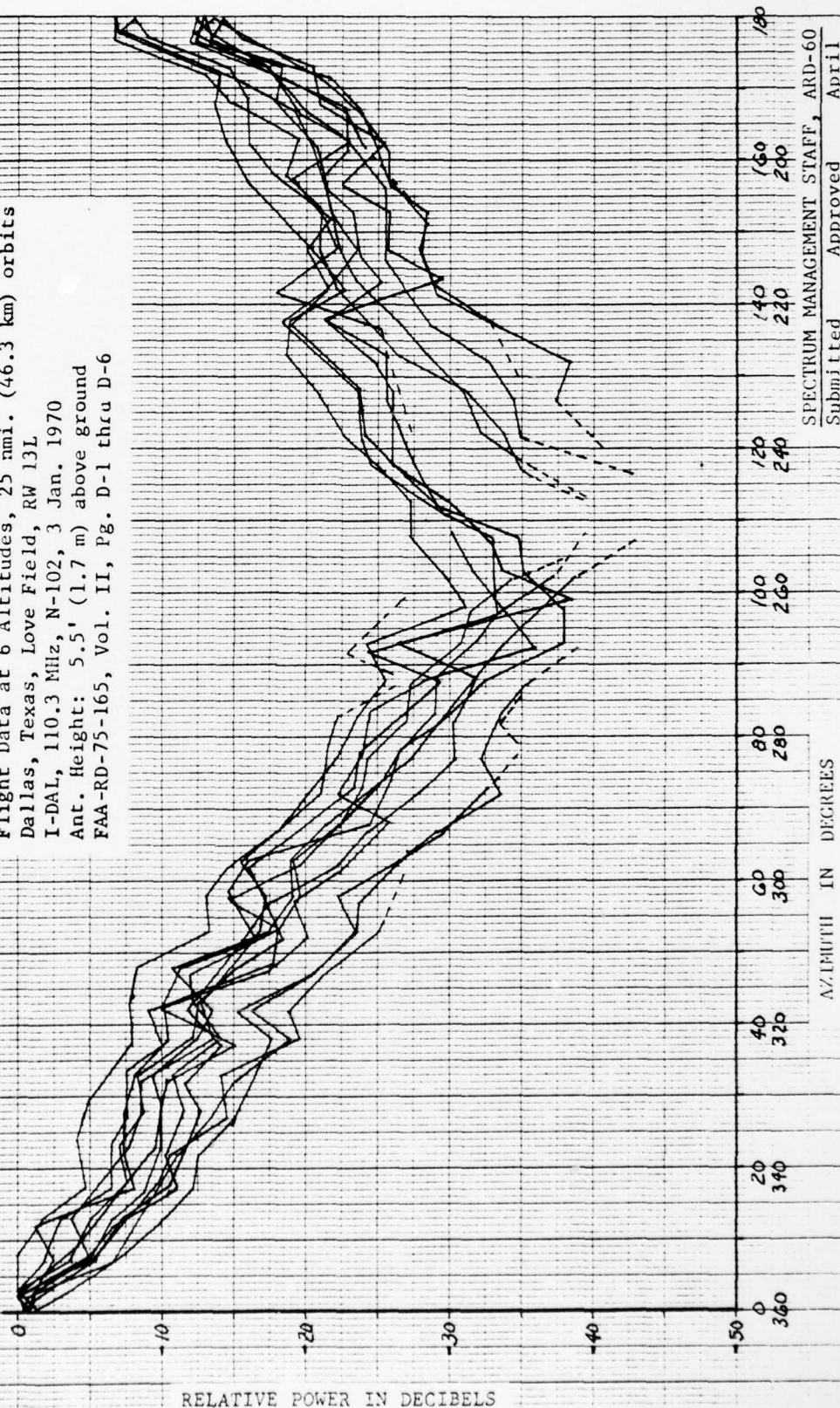


FIGURE L 3

SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted R.D. SMITH
Approved J.L. PIERZGA
March 1977

MEASURED V-RING ANTENNA PATTERN

Standard 15 Element Localizer Array
 Flight Data at 6 Altitudes, 25 nmi. (46.3 km) orbits
 Dallas, Texas, Love Field, RW 13L
 I-DAL, 110.3 MHz, N-102, 3 Jan. 1970
 Ant. Height: 5.5' (1.7 m) above ground
 FAA-RD-75-165, Vol. II, Pg. D-1 thru D-6

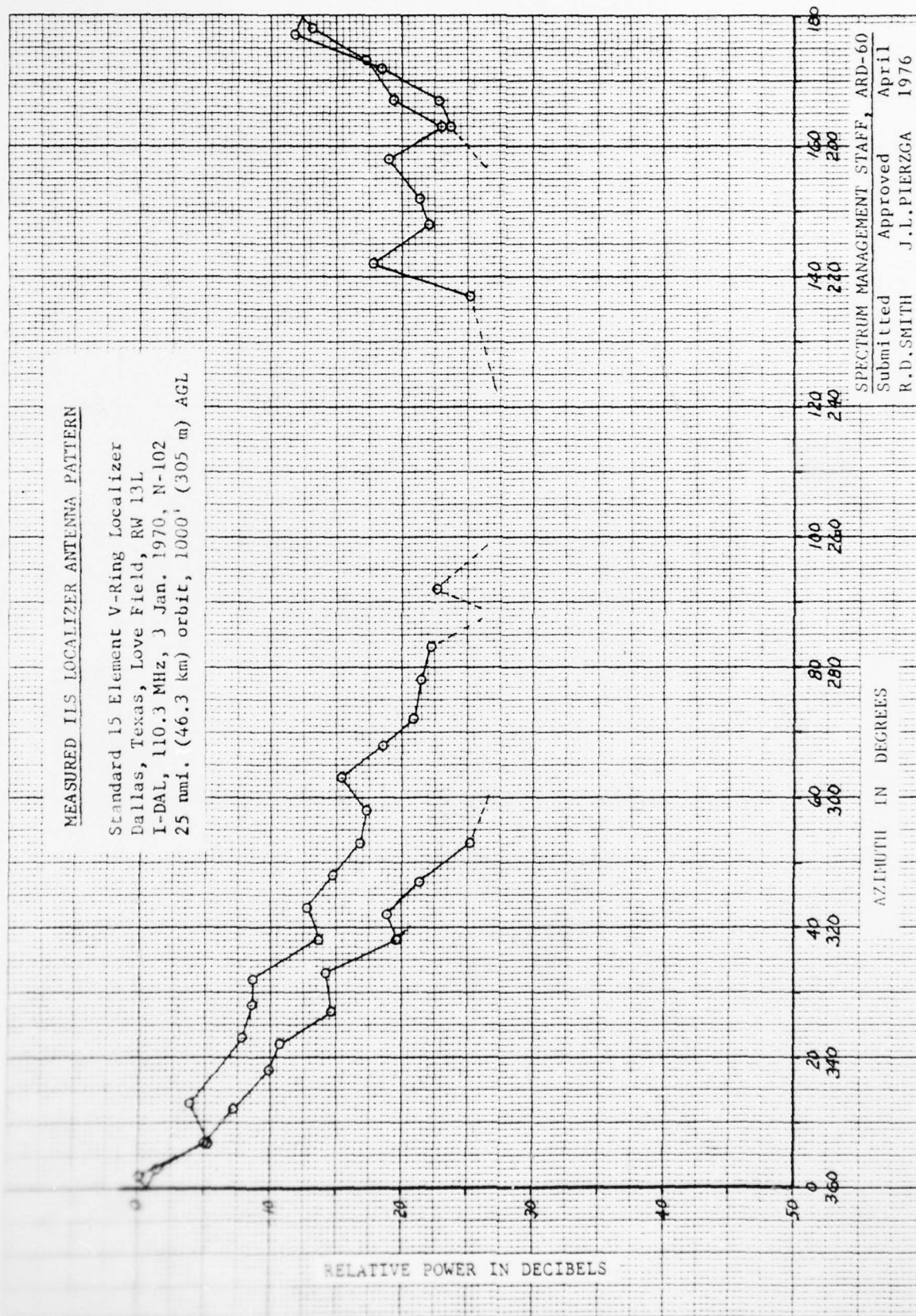


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FIGURE L 4

MEASURED IIS LOCALIZER ANTENNA PATTERN

Standard 15 Element V-Ring Localizer
 Dallas, Texas, Love Field, RW 13L
 I-DAL, 110.3 MHz, 3 Jan. 1970, N-102
 25 nmi. (46.3 km) orbit, 1000' (305 m) AGL



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 Approved J.L. PIERZGA
 April 1976

FIGURE L 5

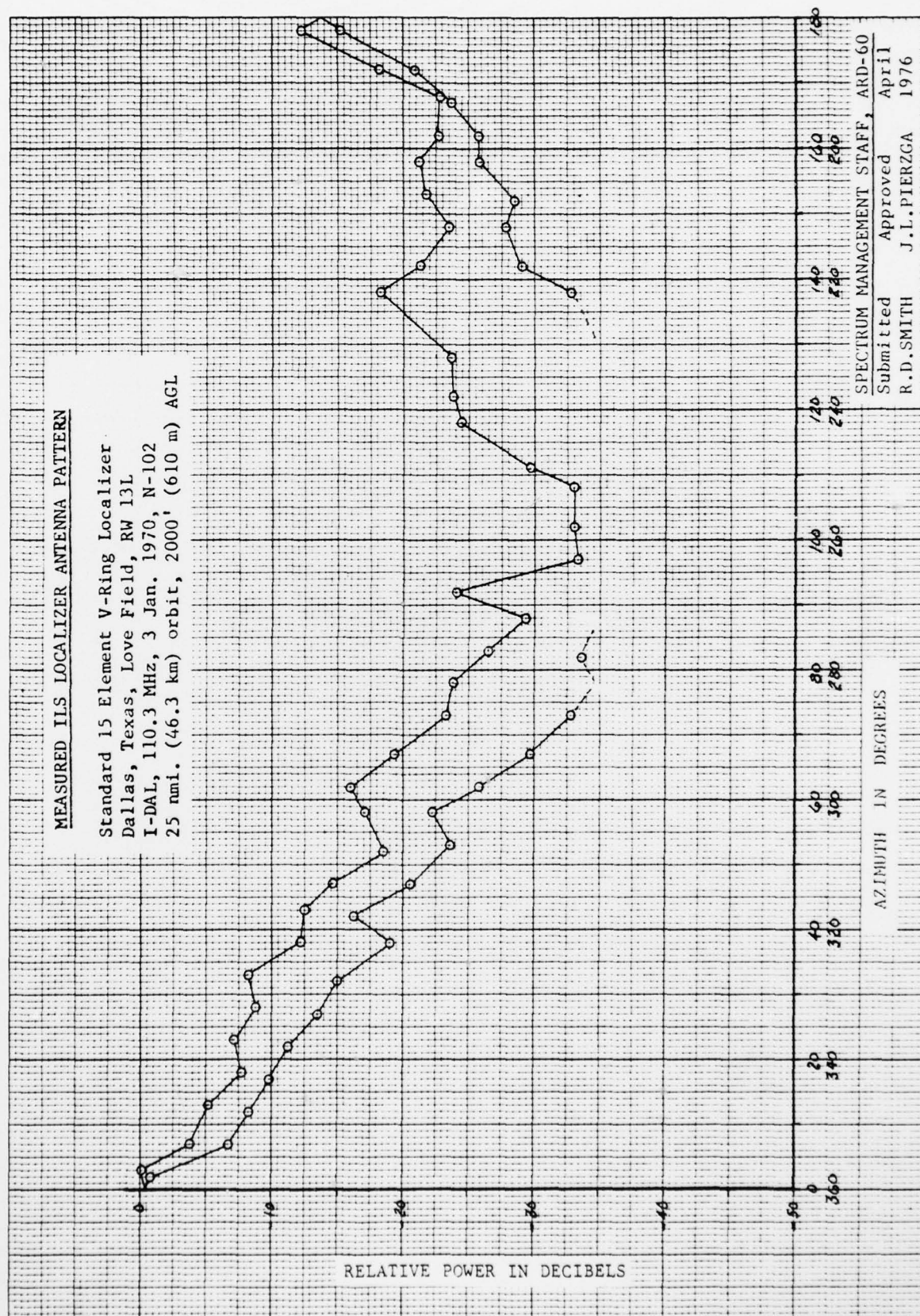


FIGURE 1. 6

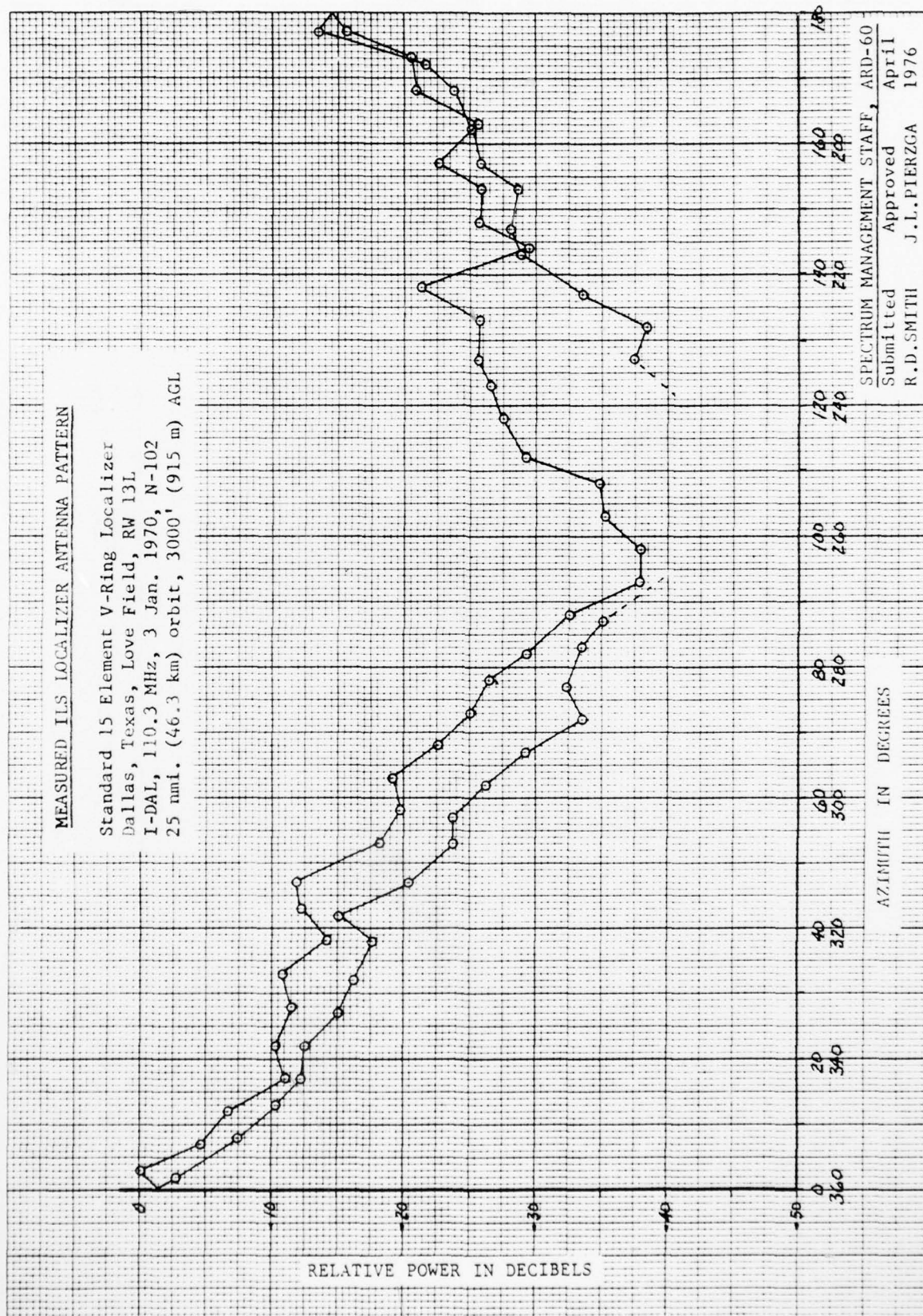


FIGURE L 7

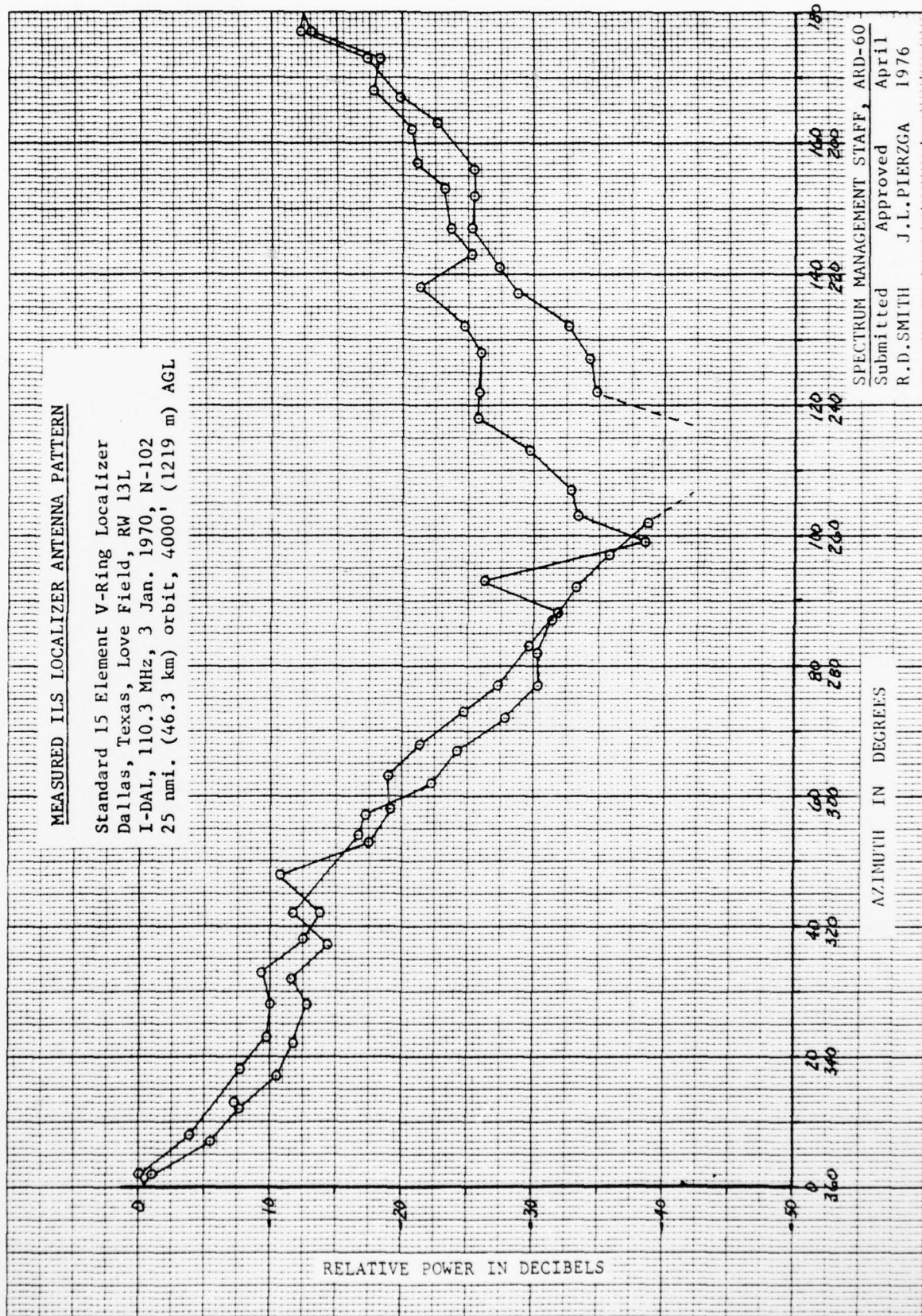


FIGURE L 8

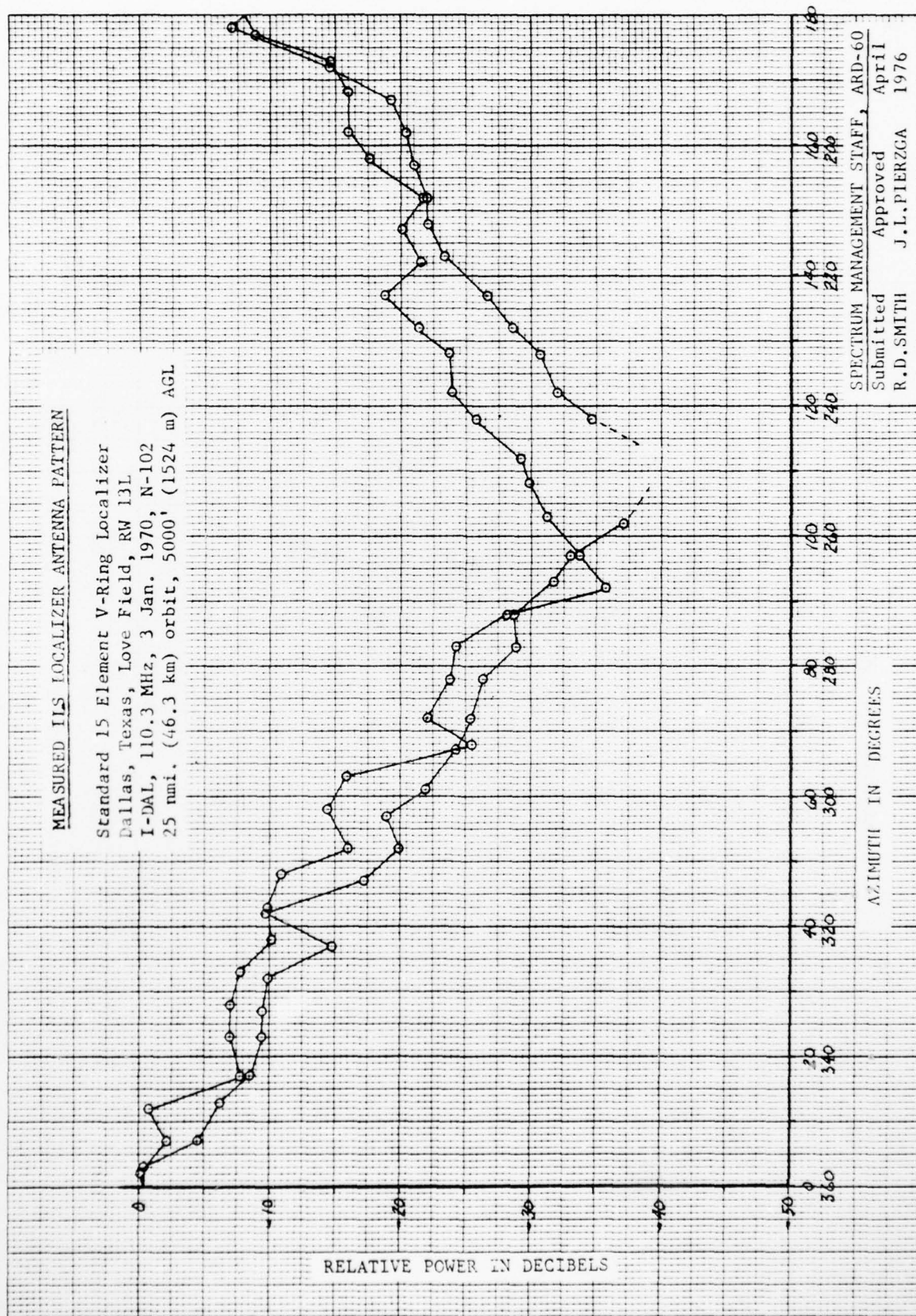


FIGURE L 9

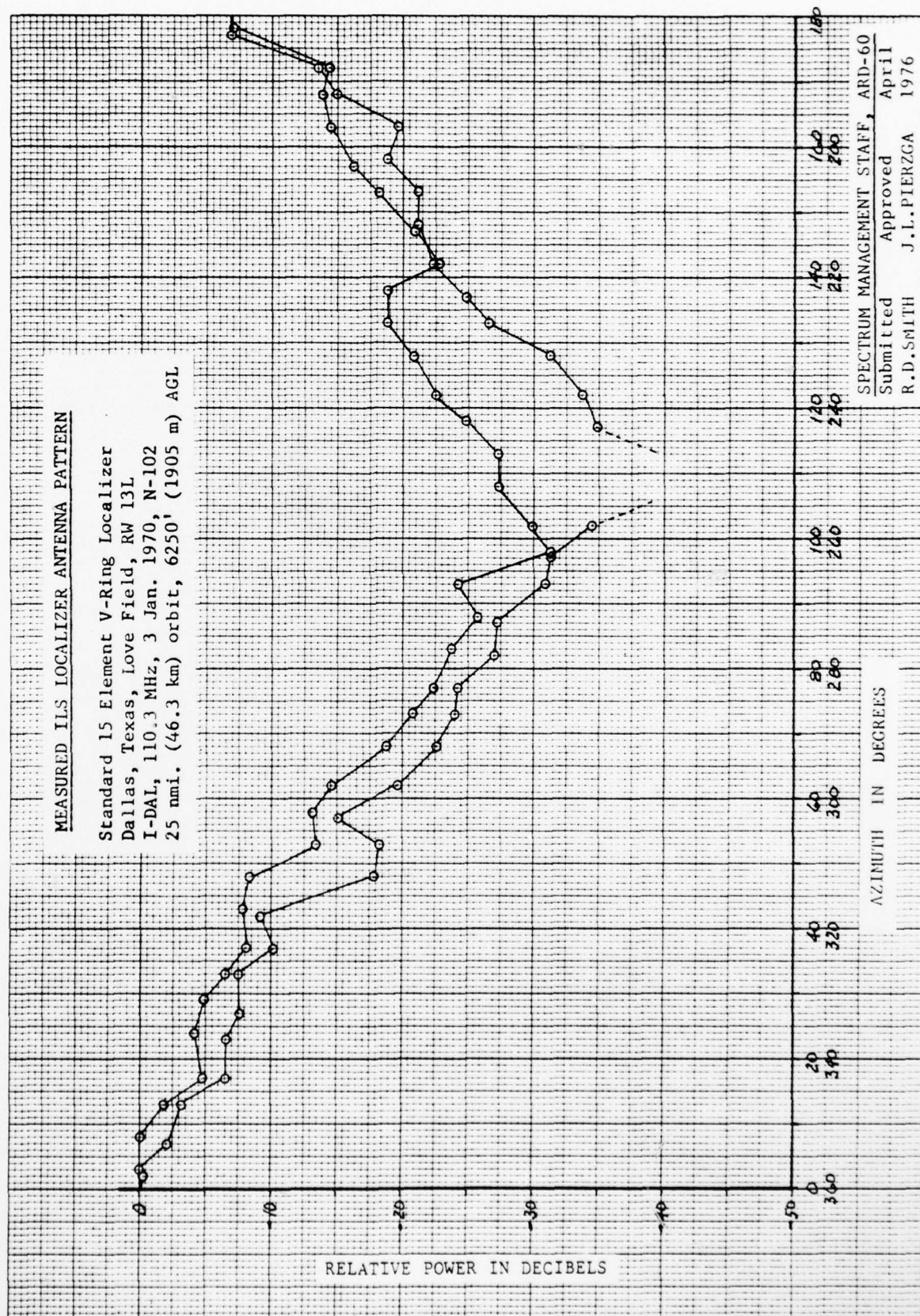
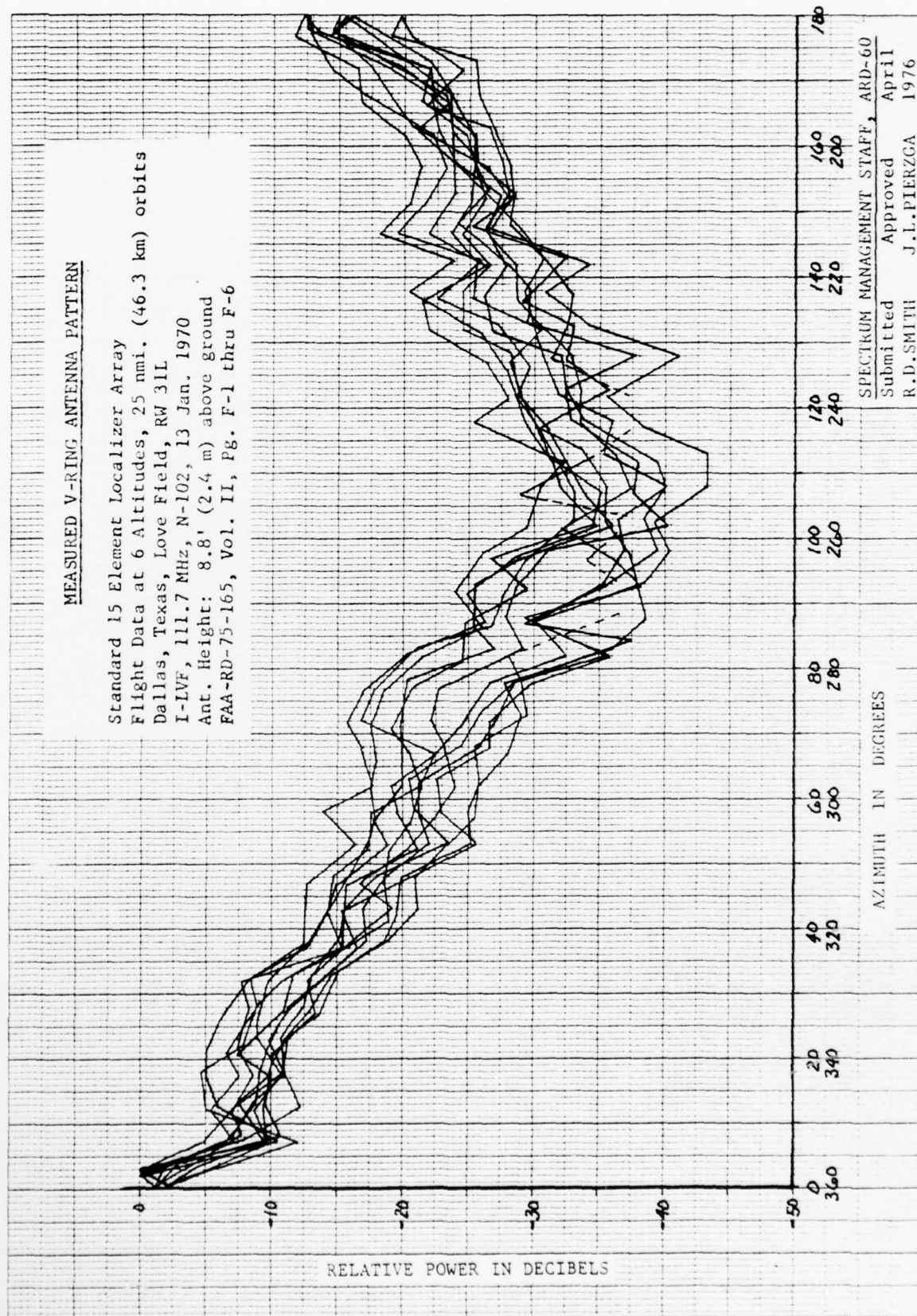


FIGURE L 10

MEASURED V-RING ANTENNA PATTERN

Standard 15 Element Localizer Array
Flight Data at 6 Altitudes, 25 nmi. (46.3 km) orbits
Dallas, Texas, Love Field, RW 31L
I-LVF, 111.7 MHz, N-102, 13 Jan. 1970
Ant. Height: 8.8' (2.4 m) above ground
FAA-RD-75-165, Vol. II, Pg. F-1 thru F-6



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FIGURE L 11

MEASURED ILS LOCALIZER ANTENNA PATTERN

Standard 15 Element V-Ring Localizer
 Dallas, Texas, Love Field, RW 31L
 I-LVF, 111.7 MHz, 3 Jan. 1970, N-102
 25 nmi. (46.3 km) orbit, 1000' (305 m) AGL

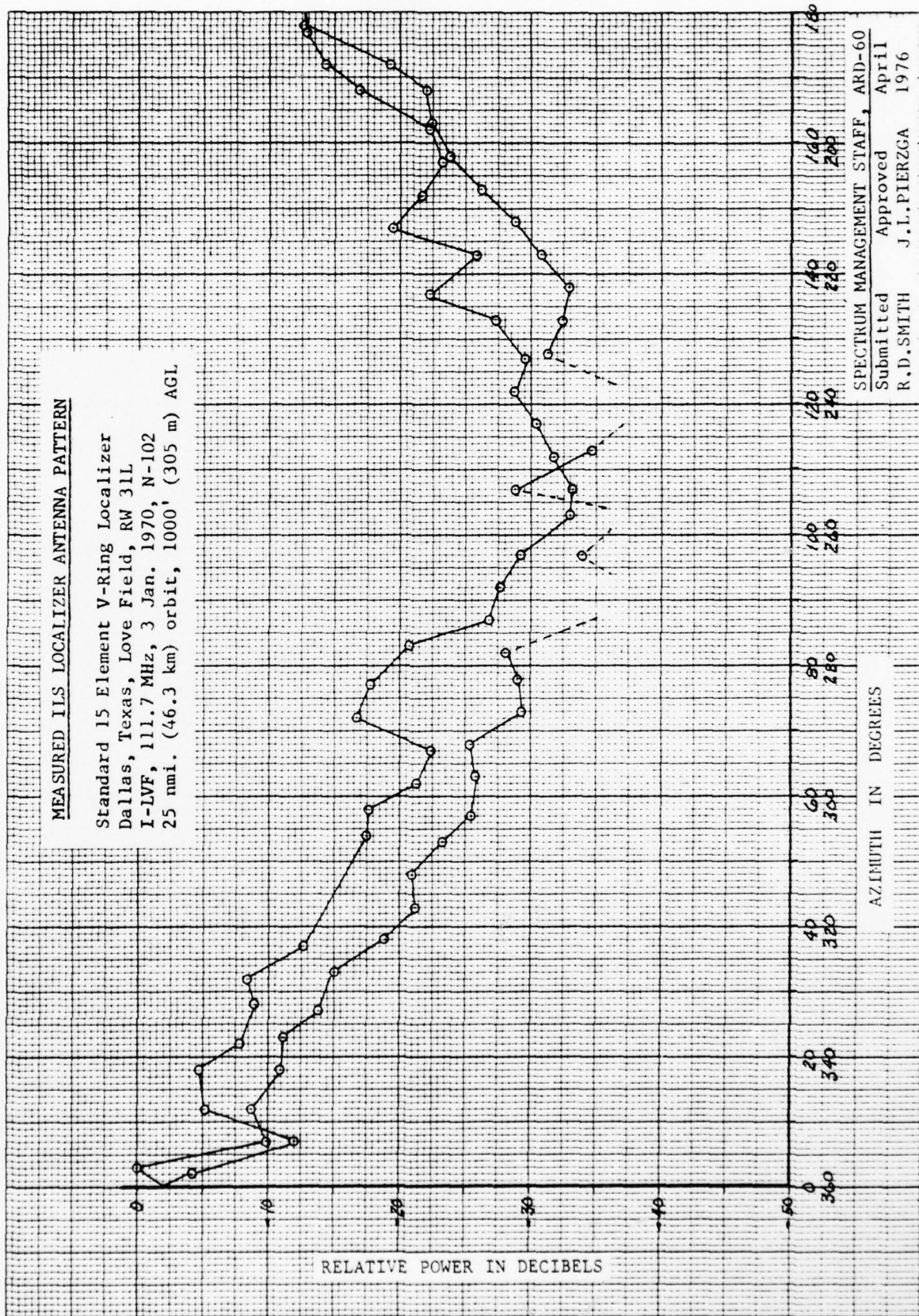
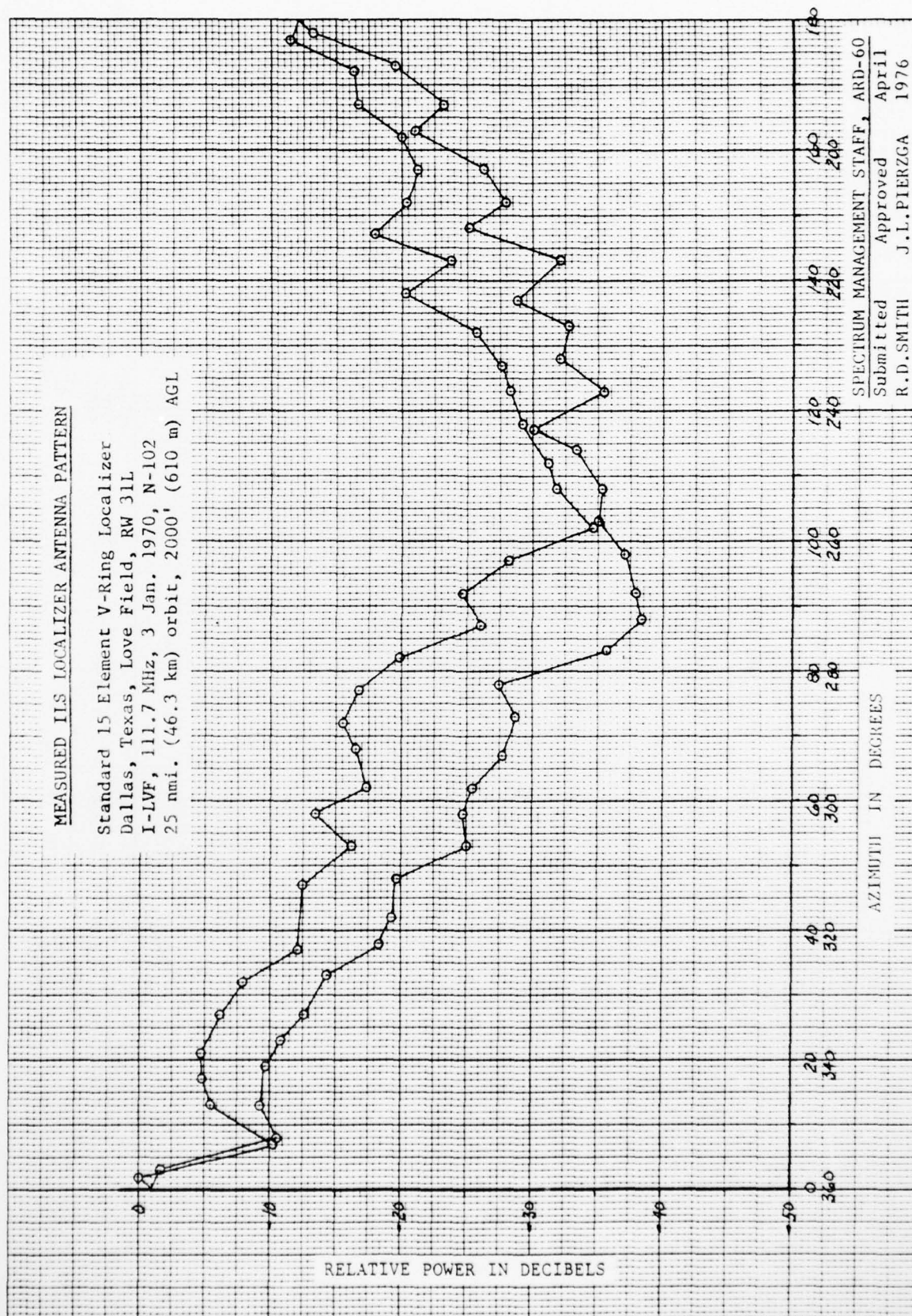


FIGURE L 12

SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D. SMITH
 Approved J.L. PIERZGA
 April 1976

MEASURED ILS LOCALIZER ANTENNA PATTERN

Standard 15 Element V-Ring Localizer
Dallas, Texas, Love Field, RW 31L
I-LVF, 111.7 MHz, 3 Jan. 1970, N-102
25 nmi. (46.3 km) orbit, 2000' (610 m) AGL



SPECTRUM MANAGEMENT STAFF, ARD-60
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FIGURE L 13

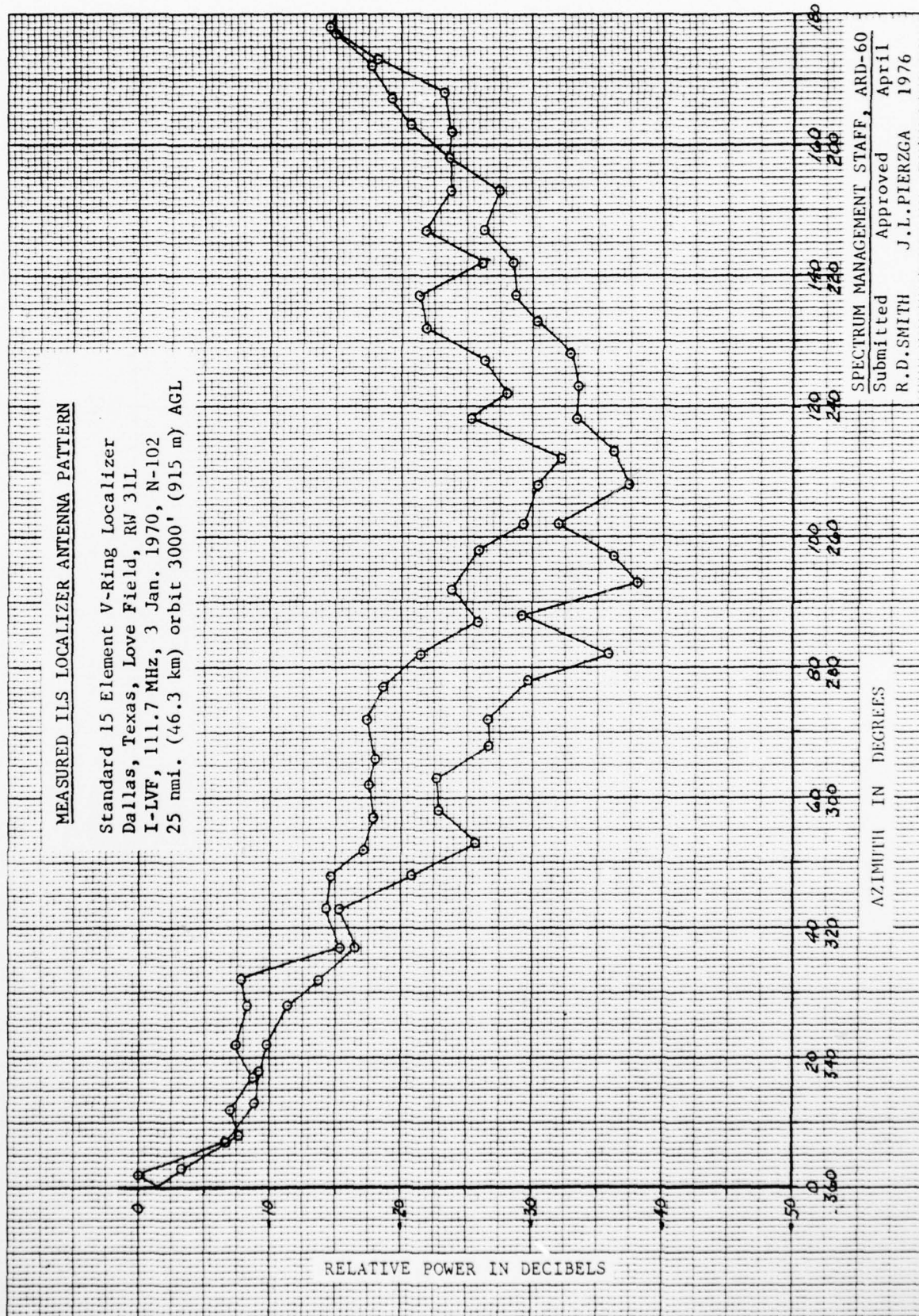


FIGURE L 14

MEASURED ILS LOCALIZER ANTENNA PATTERN

Standard 15 Element V-Ring Localizer
 Dallas, Texas, Love Field, RW 31L
 I-LVF, 111.7 MHz, 3 Jan. 1970, N-102
 25 nmi. (46.3 km) orbit 4000' (1219 m) AGL

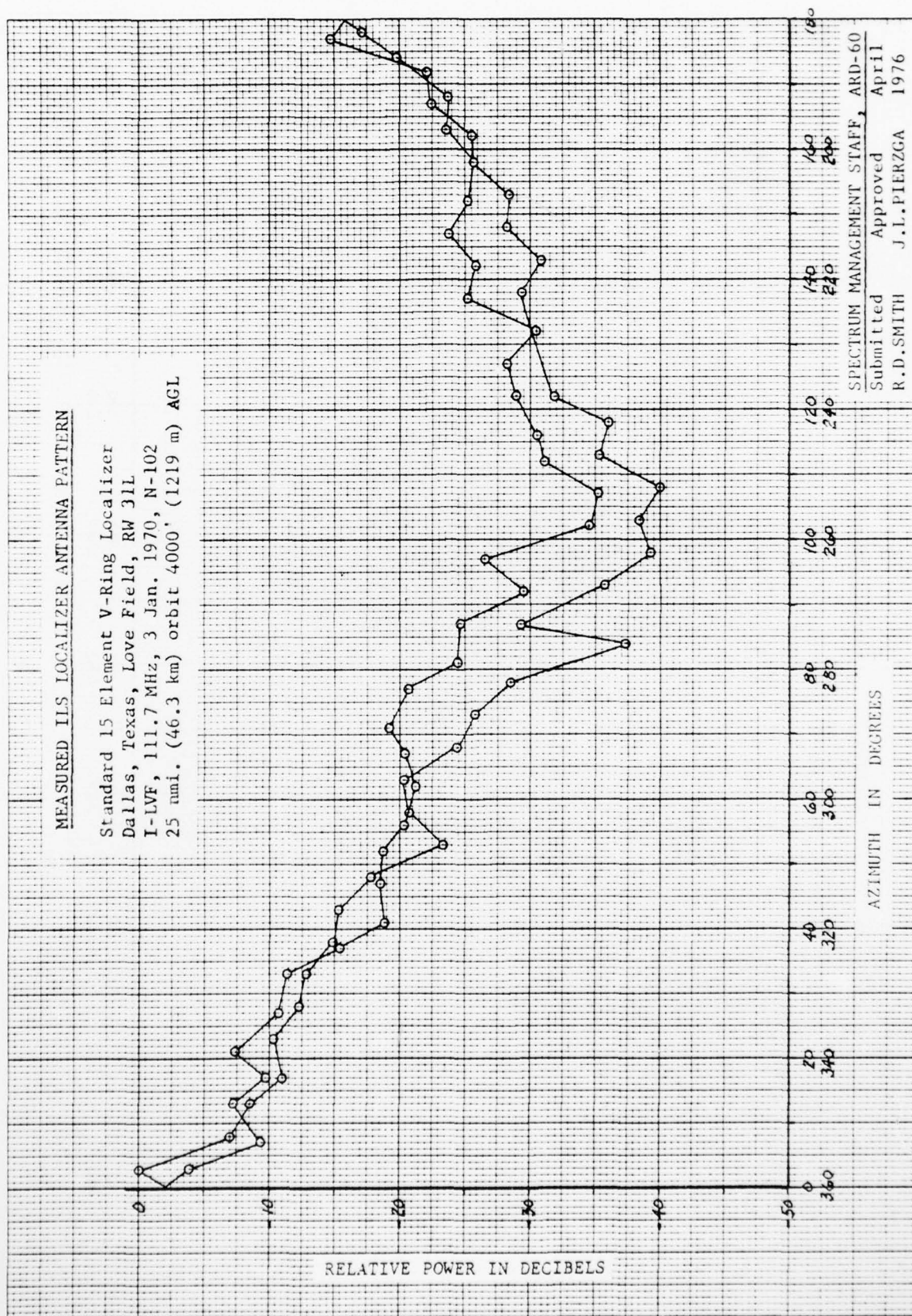
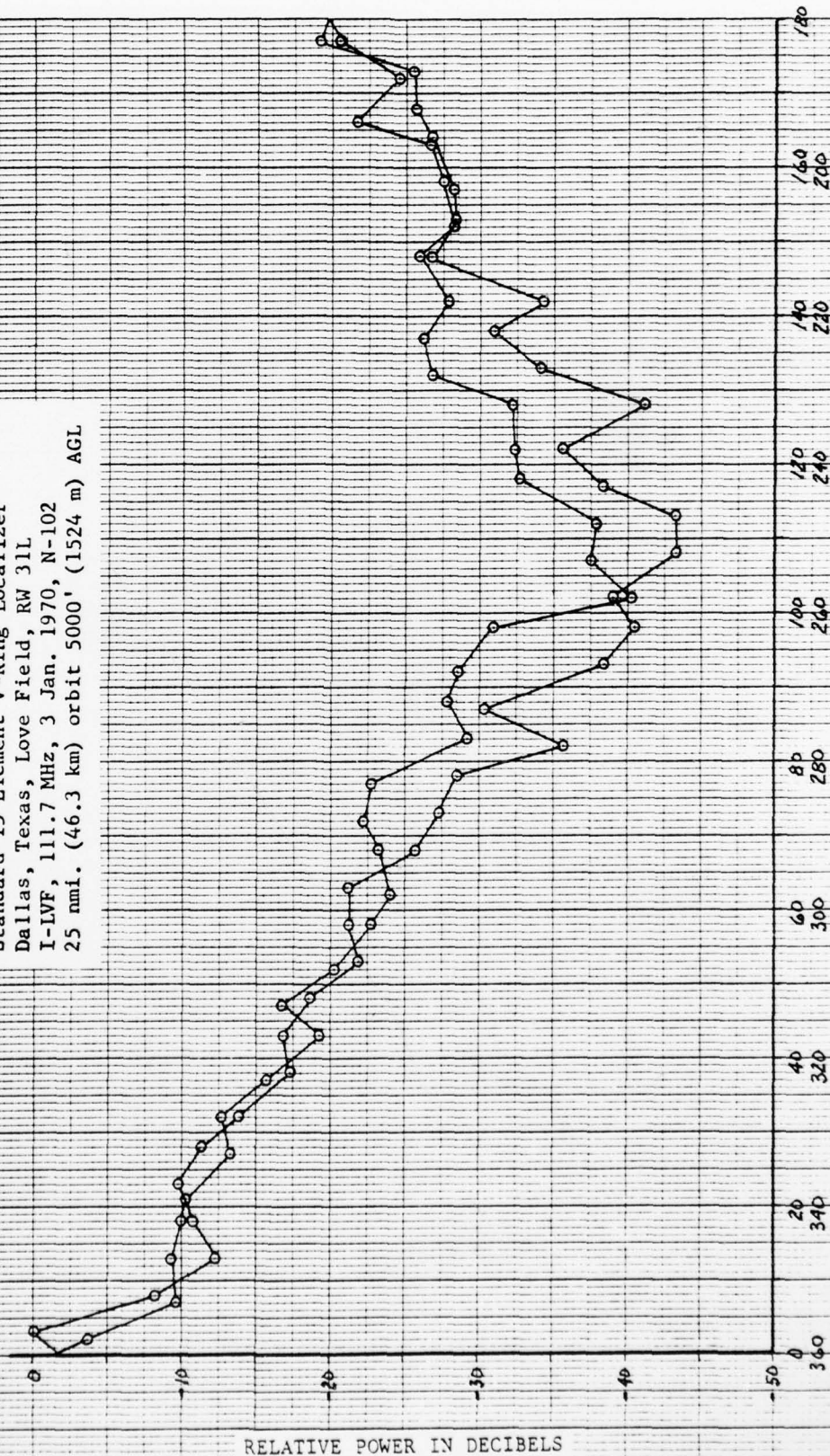


FIGURE L 15

MEASURED ILS LOCALIZER ANTENNA PATTERN

Standard 15 Element V-Ring Localizer
 Dallas, Texas, Love Field, RW 31L
 I-LVF, 111.7 MHz, 3 Jan. 1970, N-102
 25 nmi. (46.3 km) orbit 5000' (1524 m) AGL

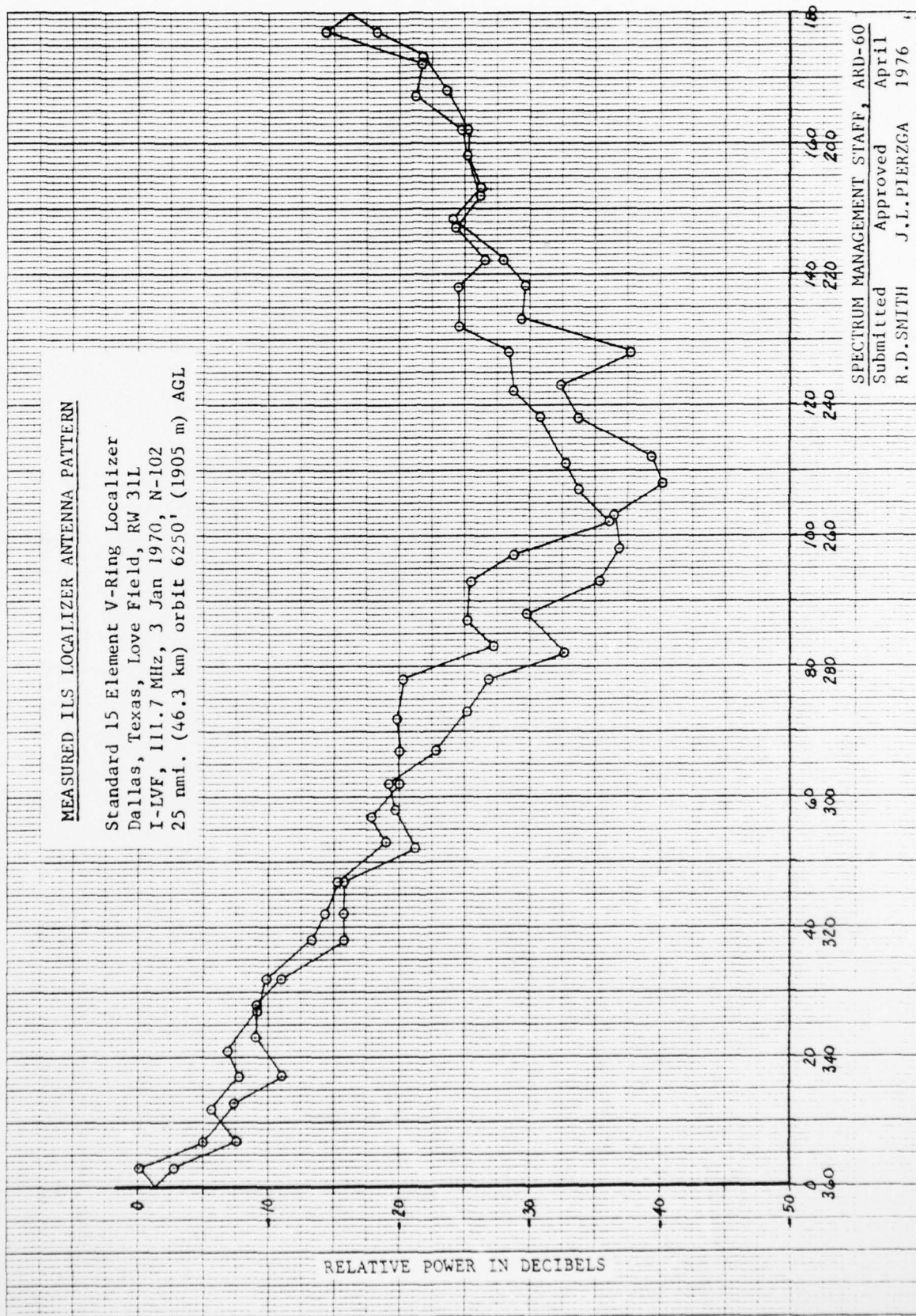


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 Submitted R.D.SMITH J.I.PIERZGA Approved April 1976

FIGURE L 16

MEASURED ILS LOCALIZER ANTENNA PATTERN

Standard 15 Element V-Ring Localizer
Dallas, Texas, Love Field, RW 31L
I-LVF, 111.7 MHz, 3 Jan 1970, N-102
25 nmi. (46.3 km) orbit 6250' (1905 m) AGL



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Submitted R.D. SMITH J.L. PIERZGA
Approved April 1976

FIGURE L 17

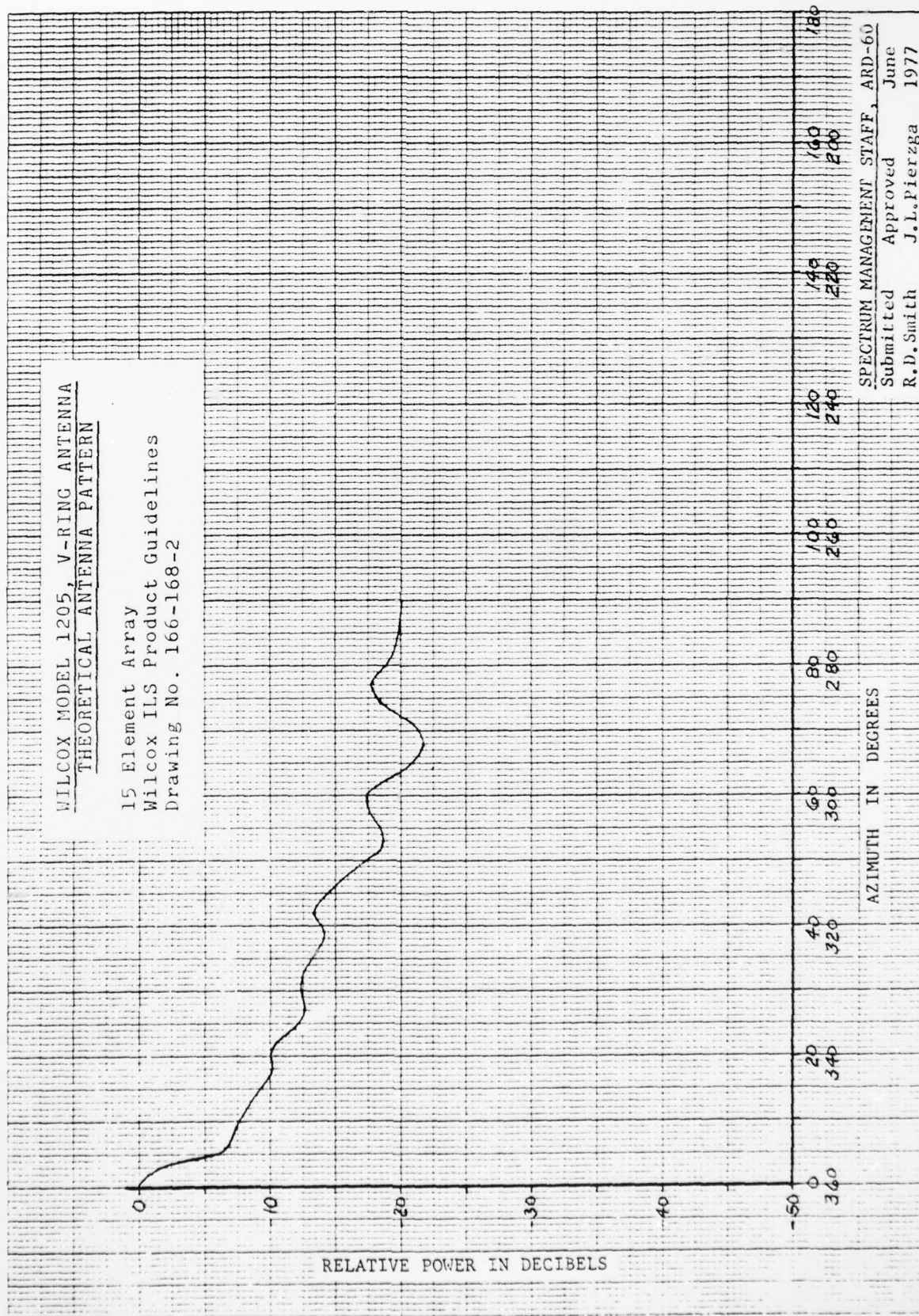


FIGURE L 18

AD-A057 935

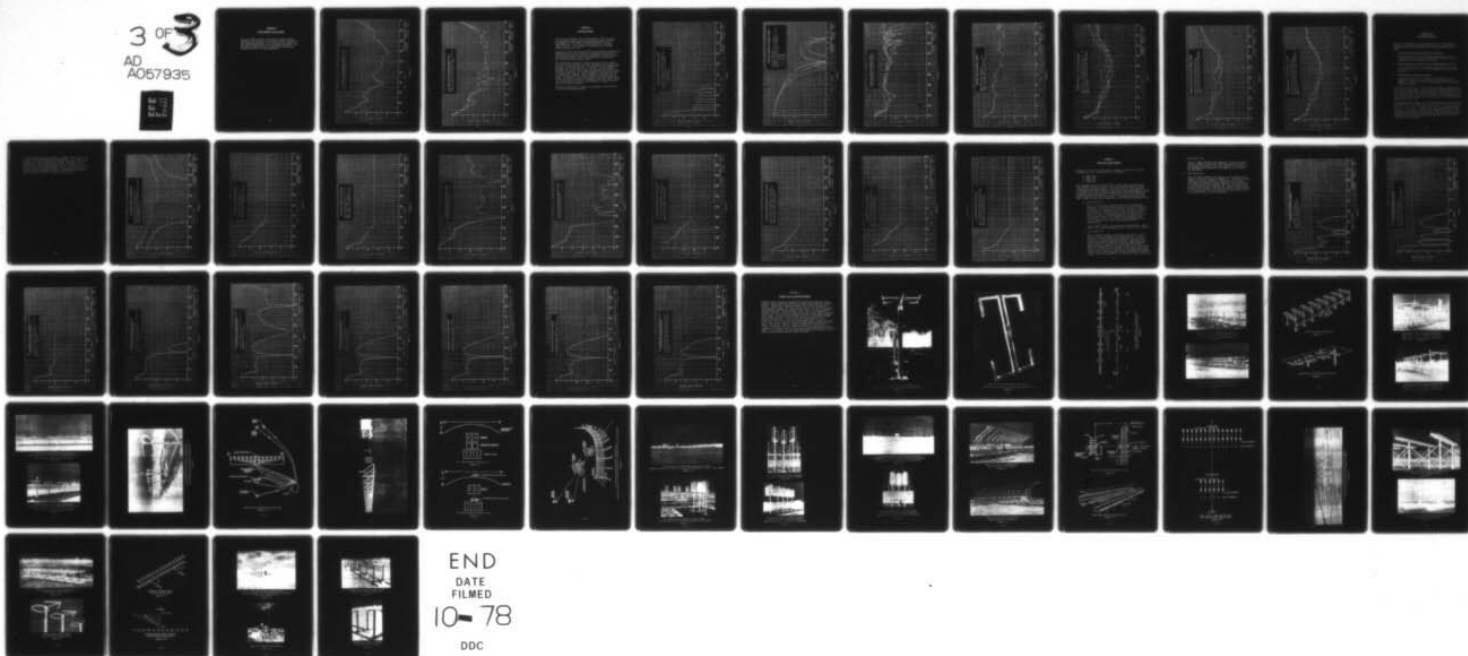
FEDERAL AVIATION ADMINISTRATION WASHINGTON D C SYSTE--ETC F/G 17/2.1
THE SELECTION OF ILS LOCALIZER ANTENNA PATTERNS FOR USE IN THE --ETC(U)
SEP 78 R D SMITH

UNCLASSIFIED

FAA-RD-77-130

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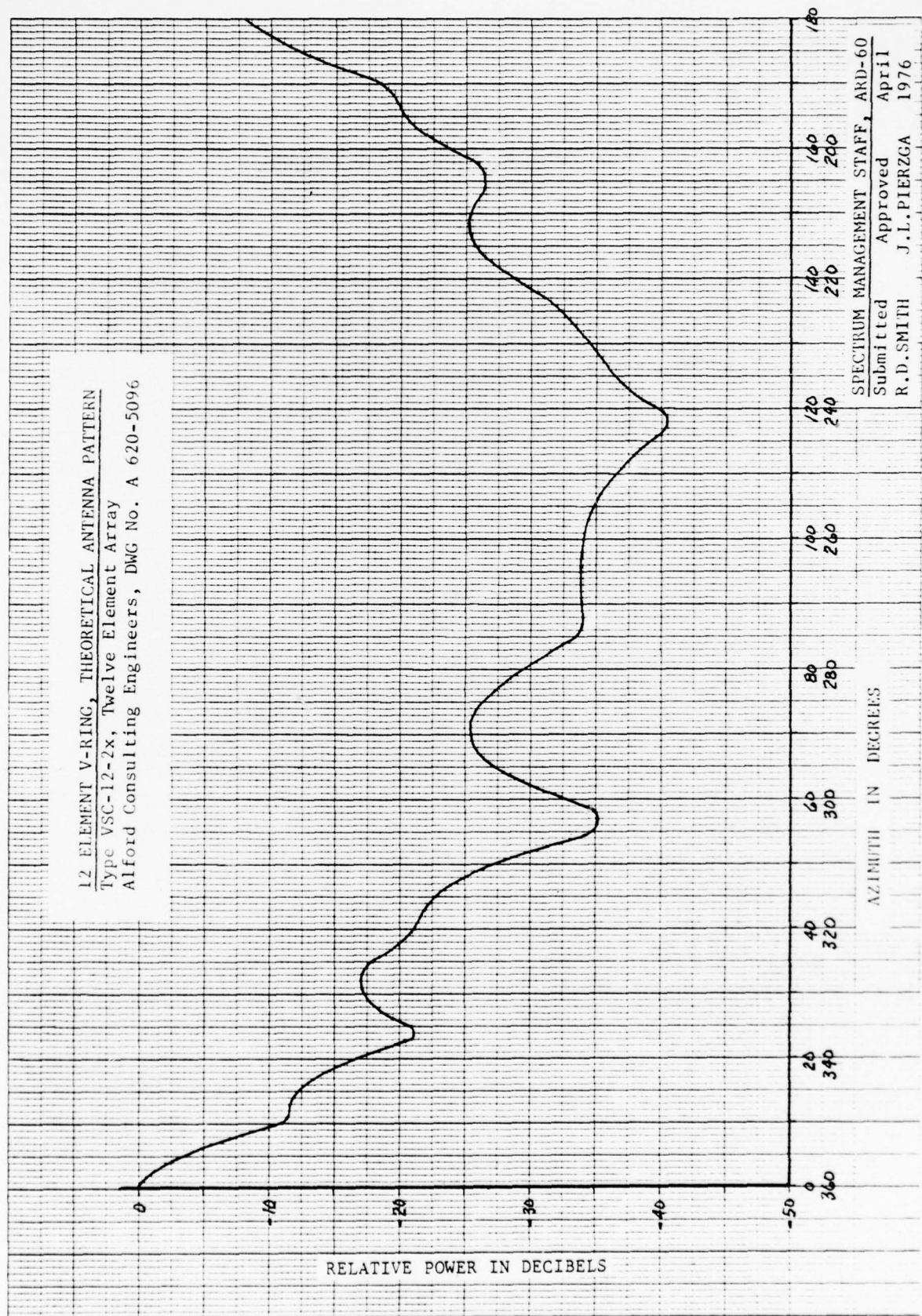


APPENDIX M

TWELVE ELEMENT V-RING ANTENNA

This is a single frequency array with 12 "V-Ring" elements. Theoretical and measured curves obtained from the manufacturer have shown good comparison. This array has been installed at West Field, Massachusetts, and at Long Beach, California. No FAA specifications are known to apply and no data has been obtained from other than the manufacturer.

12 ELEMENT V-RING, THEORETICAL ANTENNA PATTERN
 Type VSC-12-2x, Twelve Element Array
 Alford Consulting Engineers, DWG No. A 620-5096



SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D.SMITH
 Approved J.L.PIERZGA
 April 1976

FIGURE M 1

12 ELEMENT V-RING, MEASURED ANTENNA PATTERN
 Type VSC-12-2x, Twelve Element Array
 Alford Consulting Engineers, DWG No. A 620-5096
 111.9 MHz, Run No. 2, 17 July 73, NAFEC

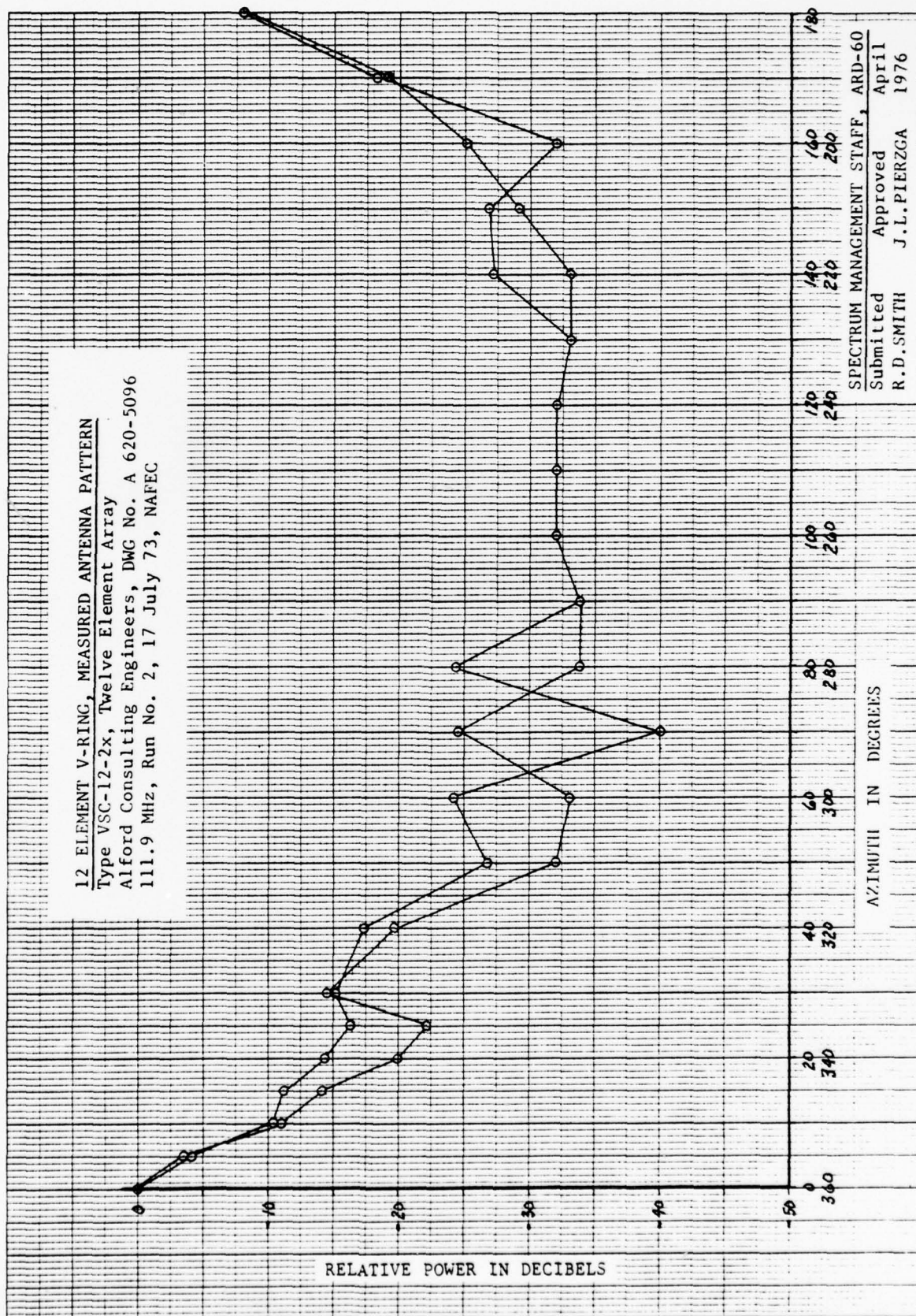


FIGURE M 2

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 April 1976

APPENDIX N

WAVEGUIDE ANTENNA

This is a two frequency, capture effect system. The course array is a waveguide consisting of a wide aperture antenna utilizing 18 waveguide-fed slot elements spaced approximately one-half wavelength apart. The clearance array consists of a standard eight loop array. Each frequency is separated from the normal carrier frequency by 4 kHz.

Theoretical curves were obtained from an FAA publication (Reference 8). Measured data was taken at two sites in January 1976 (Figure N3). The pattern obtained at Harrisburg, Pennsylvania, shows the results of rough Pennsylvania terrain. Data gathered at Virginia shows better agreement with the theoretical.

The waveguide was designed to provide the optimum carrier pattern at 110 to 111 MHz with the slot probes adjusted for the desired side-band slot current distribution. The carrier pattern's beamwidth is narrowest with minimum side lobes at 112 MHz. As the frequency decreases, the carrier pattern main lobe broadens and the side lobes increase in amplitude. The eventual minimum in the main lobe occurs at a frequency of 108 MHz. These differences are reflected in the course data taken with the spectrum analyzer at Harrisburg and at Dulles. Although the course pattern makes little or no contribution to the total pattern outside ± 12 degrees of the front course, variation of the pattern as a function of frequency is expected to have some effect within the angle.

No FAA specifications were found to be applicable to the radiation pattern of the waveguide antenna.

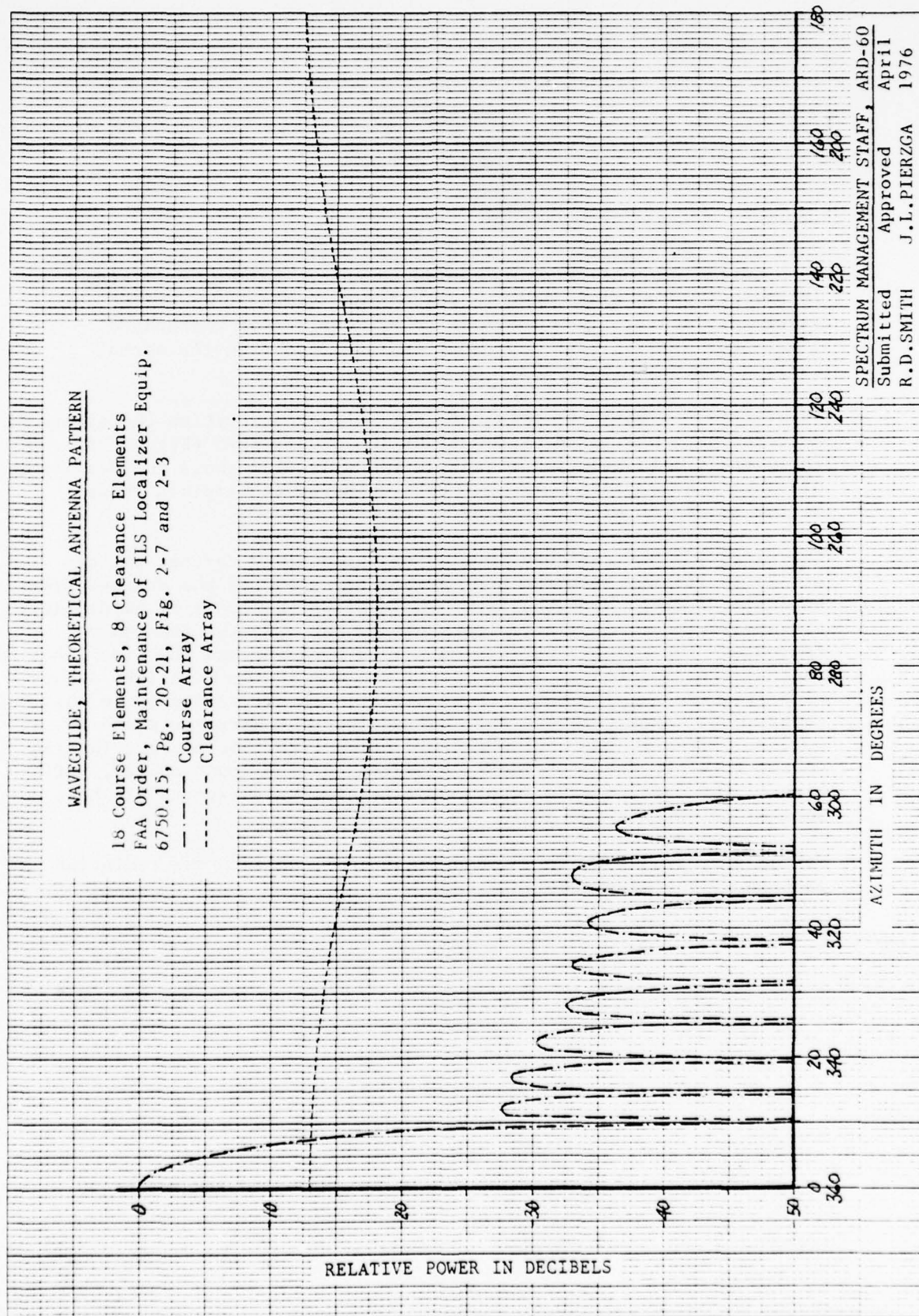
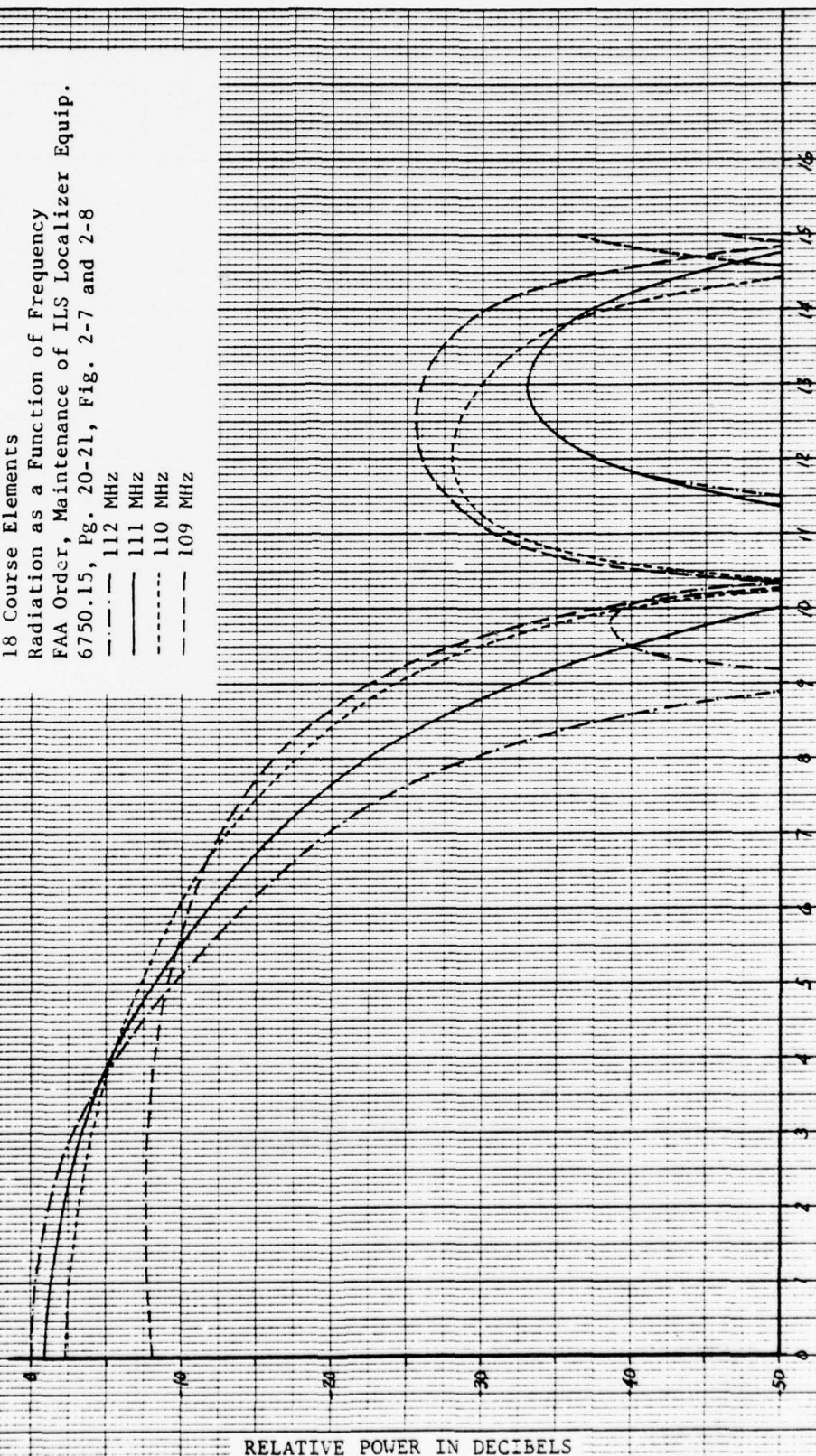


FIGURE N 1

WAVEGUIDE, THEORETICAL ANTENNA PATTERNS

18 Course Elements
 Radiation as a Function of Frequency
 FAA Order, Maintenance of ILS Localizer Equip.
 6750.15, Pg. 20-21, Fig. 2-7 and 2-8
 --- 112 MHz
 --- 111 MHz
 --- 110 MHz
 --- 109 MHz



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 Submitted Approved April
 R.D.SMITH J.L.PIERZGA 1976

AZIMUTH IN DEGREES

RELATIVE POWER IN DECIBELS

FIGURE N 2

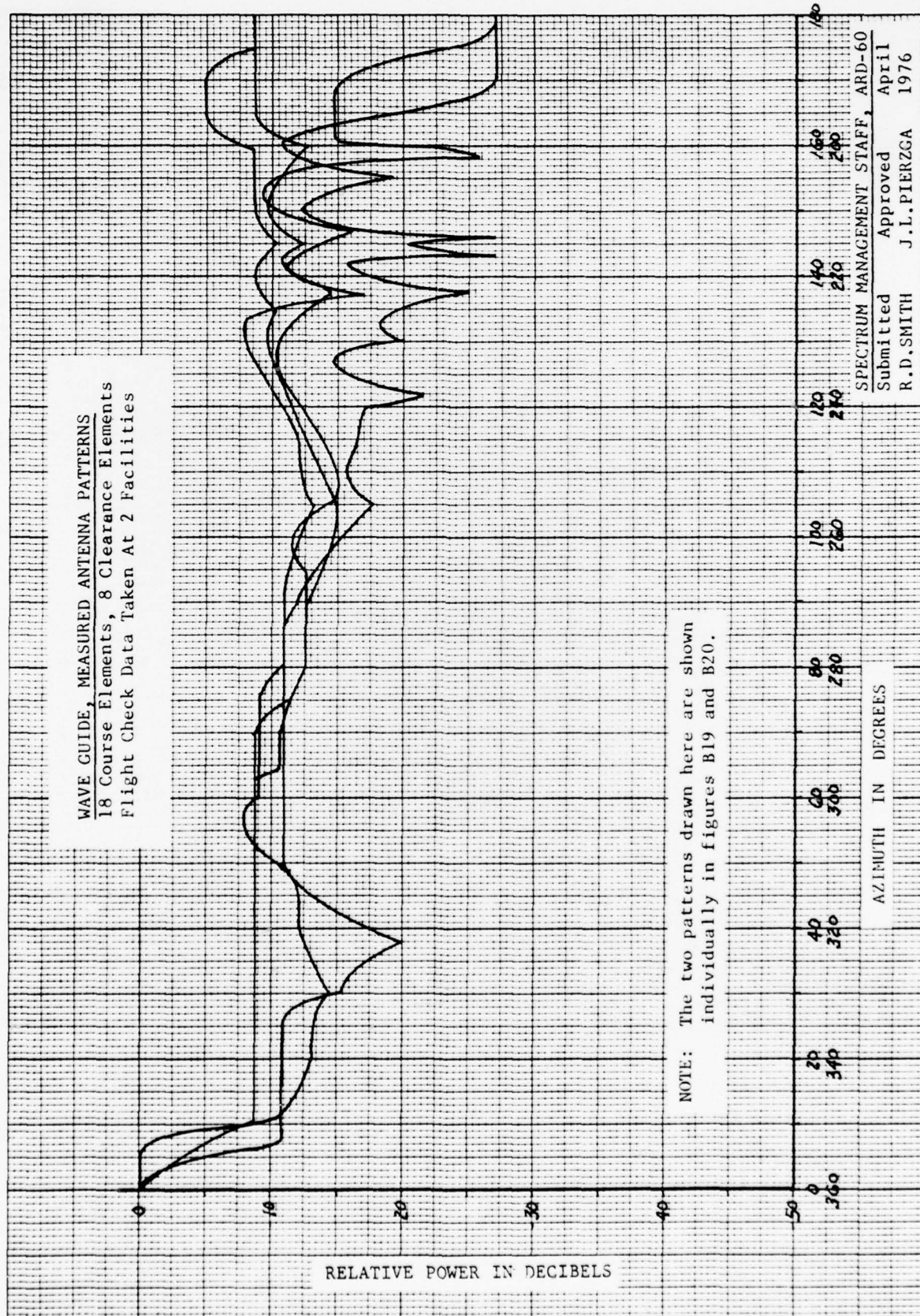


FIGURE N 3

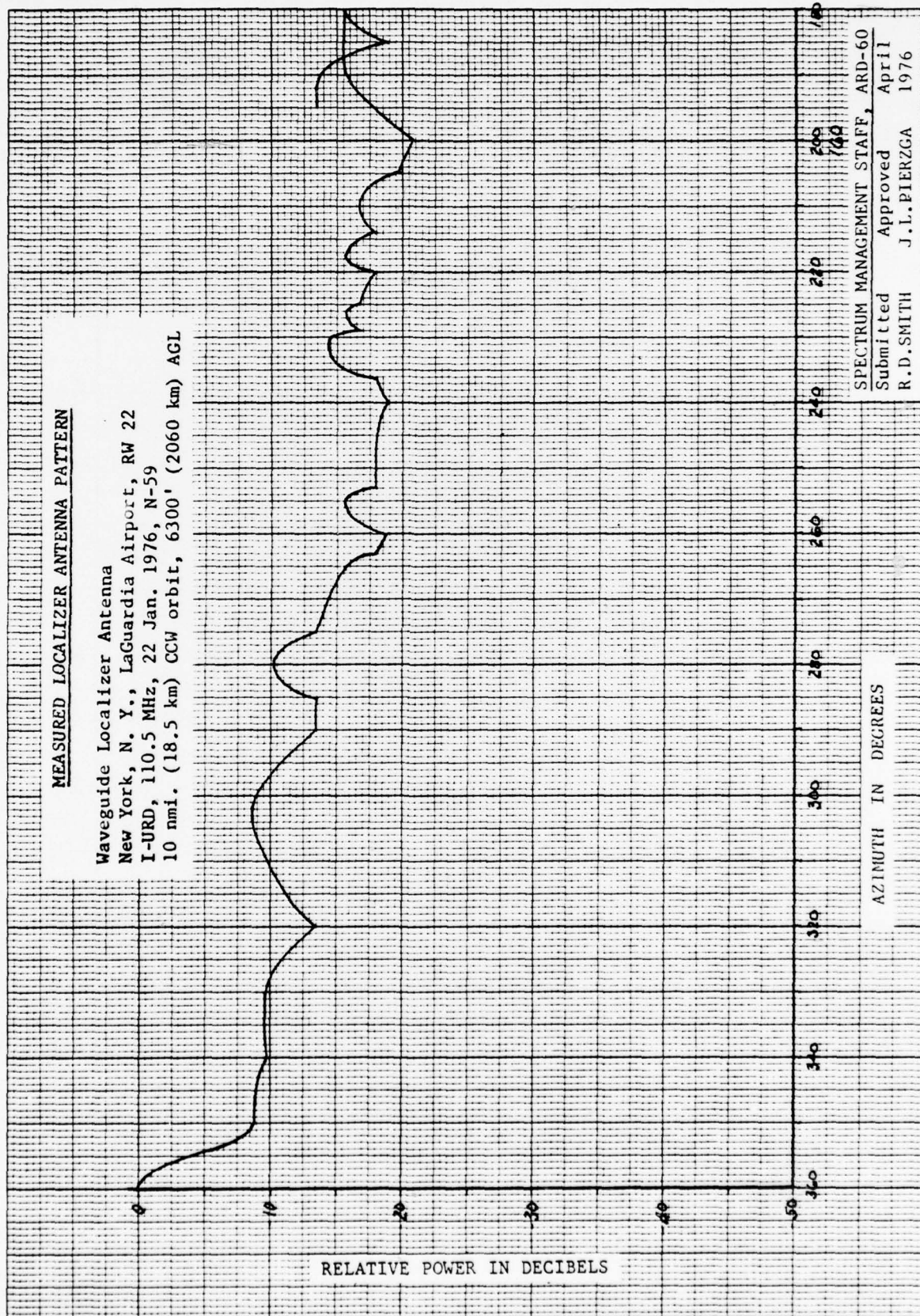


FIGURE N 4

MEASURED WAVEGUIDE LOCALIZER ANTENNA PATTERN

Flight Data at 2 altitudes, 10 nmi. (18.5 km) orbits
 Fort Worth, Texas, Meacham Field, RW 16L
 I-FTW, 109.9 MHz; Memorandum Report, VHF Nav aids
 Special Propagation Study Project NO. 483-201-01F
 Tables 32 and 33

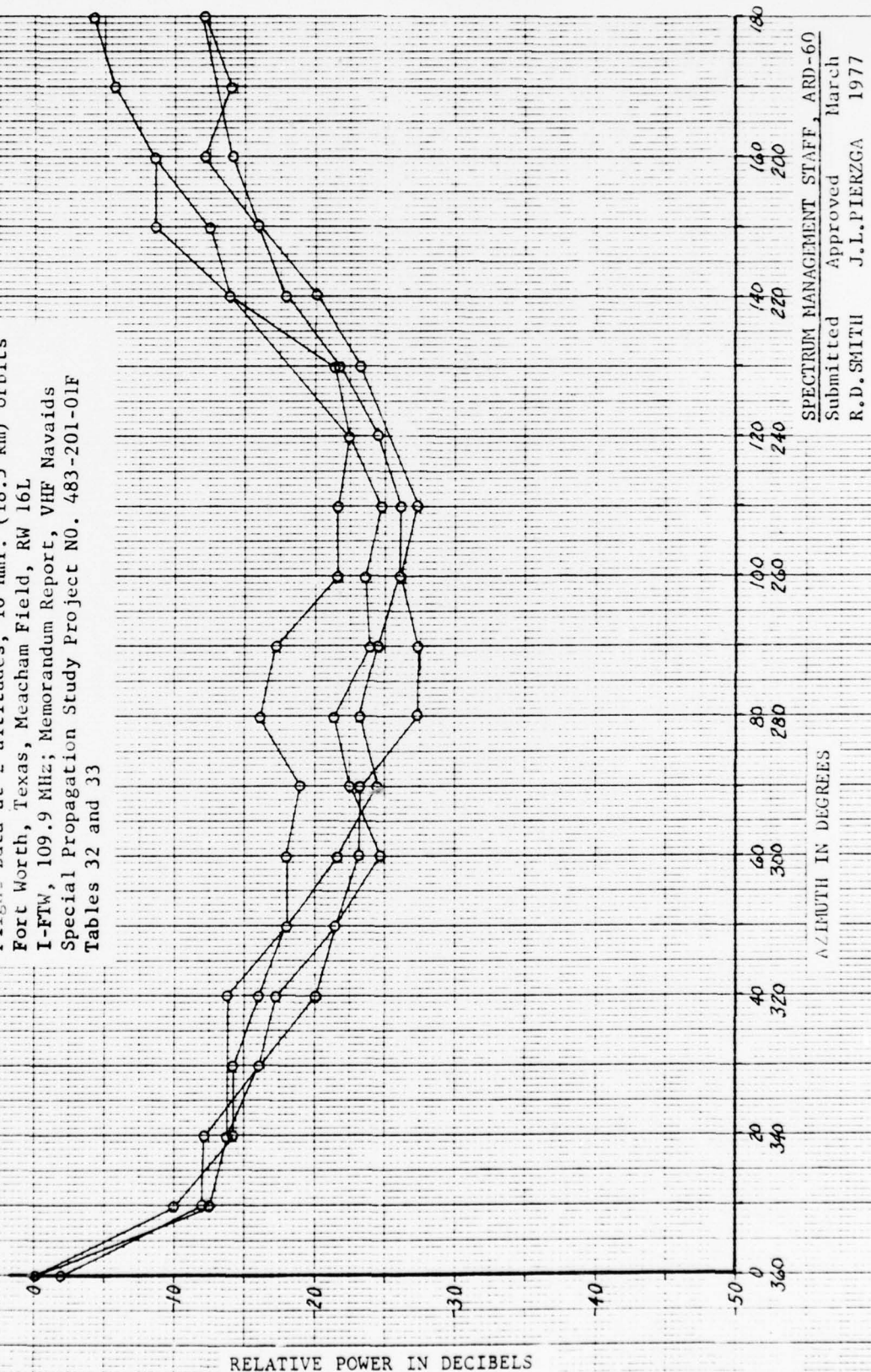


FIGURE N 5

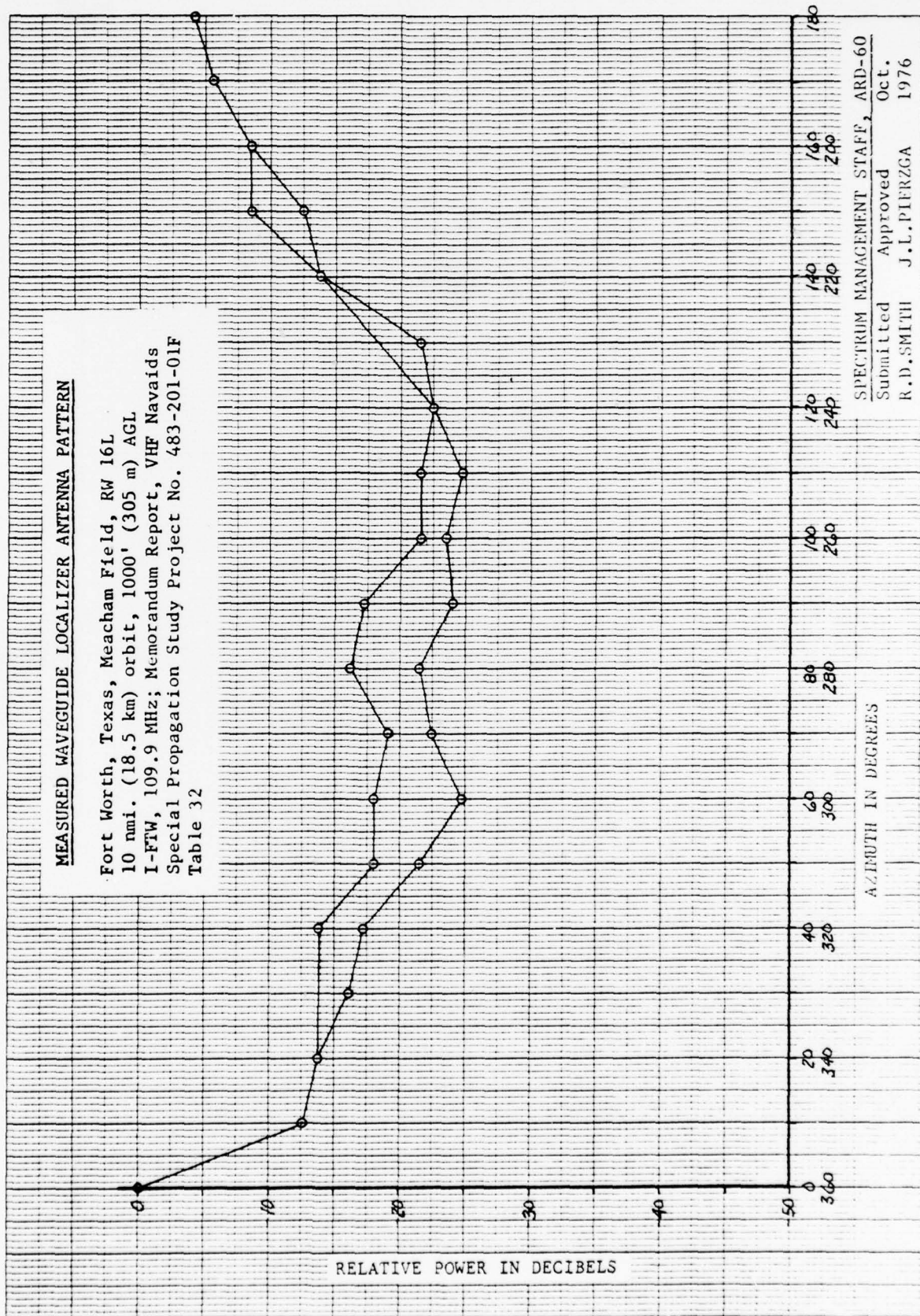


FIGURE N 6

MEASURED WAVEGUIDE LOCALIZER ANTENNA PATTERN

Fort Worth, Texas, Meacham Field, RW 16L
 10 nmi. (18.5 km) orbit, 6250' (1905 m) AGL
 I-FW, 109.9 MHz, Memorandum Report, VHF Navajids
 Special Propagation Study Project No. 483-201-01F
 Table 33

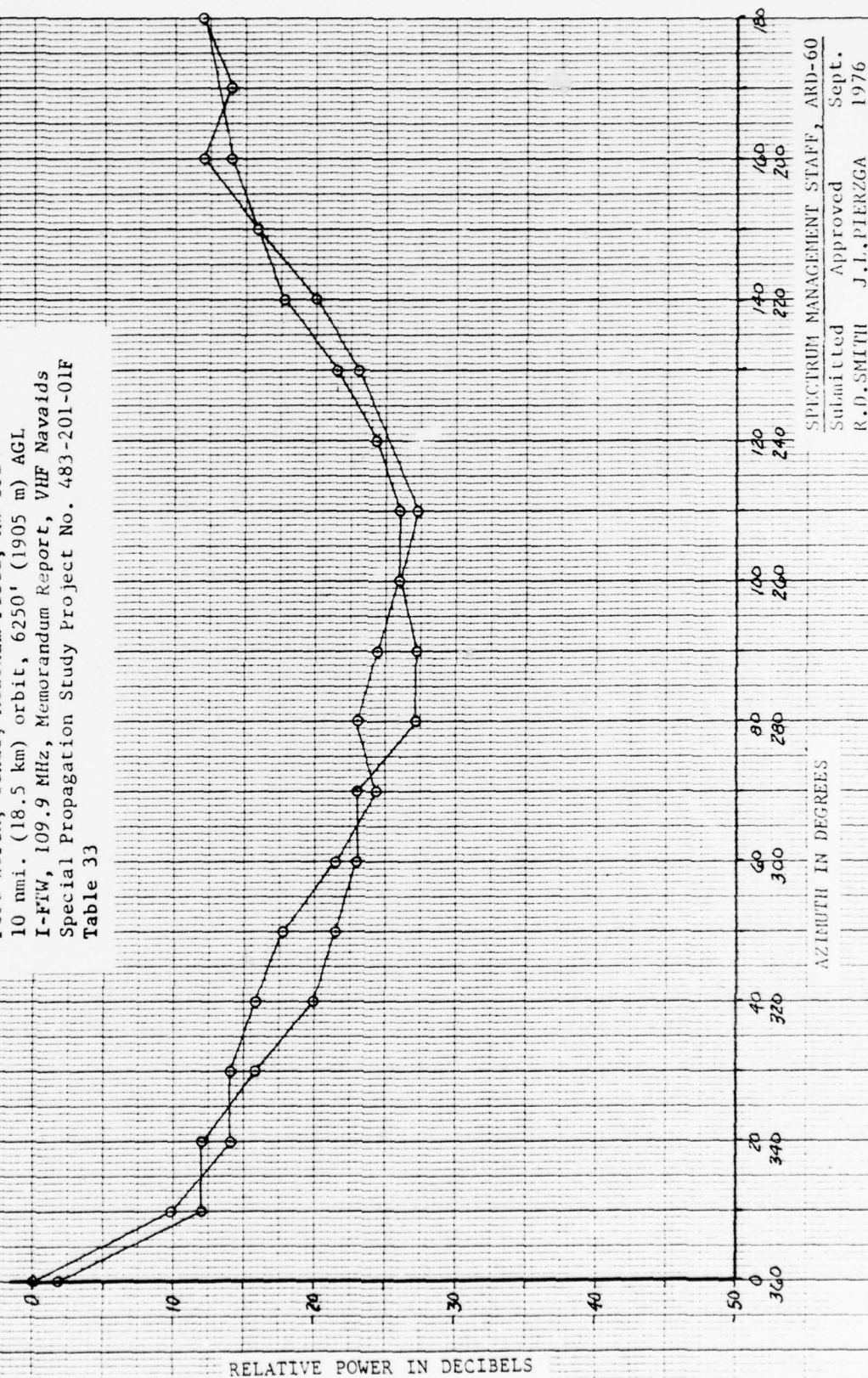


FIGURE N 7

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 Submitted Approved
 R.D. SMITH J.I. PIERZGA
 Sept. 1976

APPENDIX O
FAA SPECIFICATIONS

In the investigation of FAA specifications on ILS antenna patterns, the following specifications were considered. No other specifications applicable to antenna patterns were found.

A. FAA-E-2554, Traveling Wave Antenna Arrays

This specification is considered applicable to the traveling wave antennas manufactured by Antenna Products Corporation and by Texas Instruments.

B. FAA-E-2492/2a, Turnkey Facility Establishment for ILS

This specification is considered applicable to the log periodic dipole (L.P.D.) antenna manufactured by Wilcox Electric.

C. FAA-E-2247b, Localizer Station

This specification is considered applicable to the standard V-Ring, although there is some question as to whether it applies to all the manufacturers who provided V-Ring antennas.

Some doubts have been raised concerning whether some antennas meet the specifications, particularly the requirements on the back course radiation. Discussions with AAF-420 indicate that no test procedures were ever developed to check this part of the specification. They indicated that this had been a design goal and that no one was very concerned that the manufacturers rigidly meet this goal.

FAA measured data (taken at an elevation angle of five degrees) show that the requirement for a 26 dB front to back ratio is not met by the A.P.C. traveling wave, the T.I. traveling wave, and the Wilcox L.P.D. In spite of this, manufacturer's data (taken at an elevation angle of zero degrees) show that the Wilcox L.P.D. meets this requirement with several dB to spare. Although the circumstances closely correspond, similar manufacturer's data has not been found for the A.P.C. or T.I. traveling wave antennas.

In specifying an antenna pattern, it makes sense to specify it for an elevation angle of zero degrees. This allows the pattern to be measured using a rotating platform rather than an aircraft. With some antenna types, differences exist between the antenna pattern taken at zero degrees and the pattern taken at a higher angle. For the traveling wave and L.P.D. antennas, these differences are substantial from 50 degrees to 180 degrees off course. Substantial difference also exist for the front to back signal ratios.

ILS ANTENNA PATTERN, SPECIFICATION

Specification FAA-E-2247b, 10 Jan 1969
Pg. 4, Par. 3.7, RF Carrier Pattern
Pattern Requirements at a Minimum Distance of 2 NM
Standard V-Ring Antenna

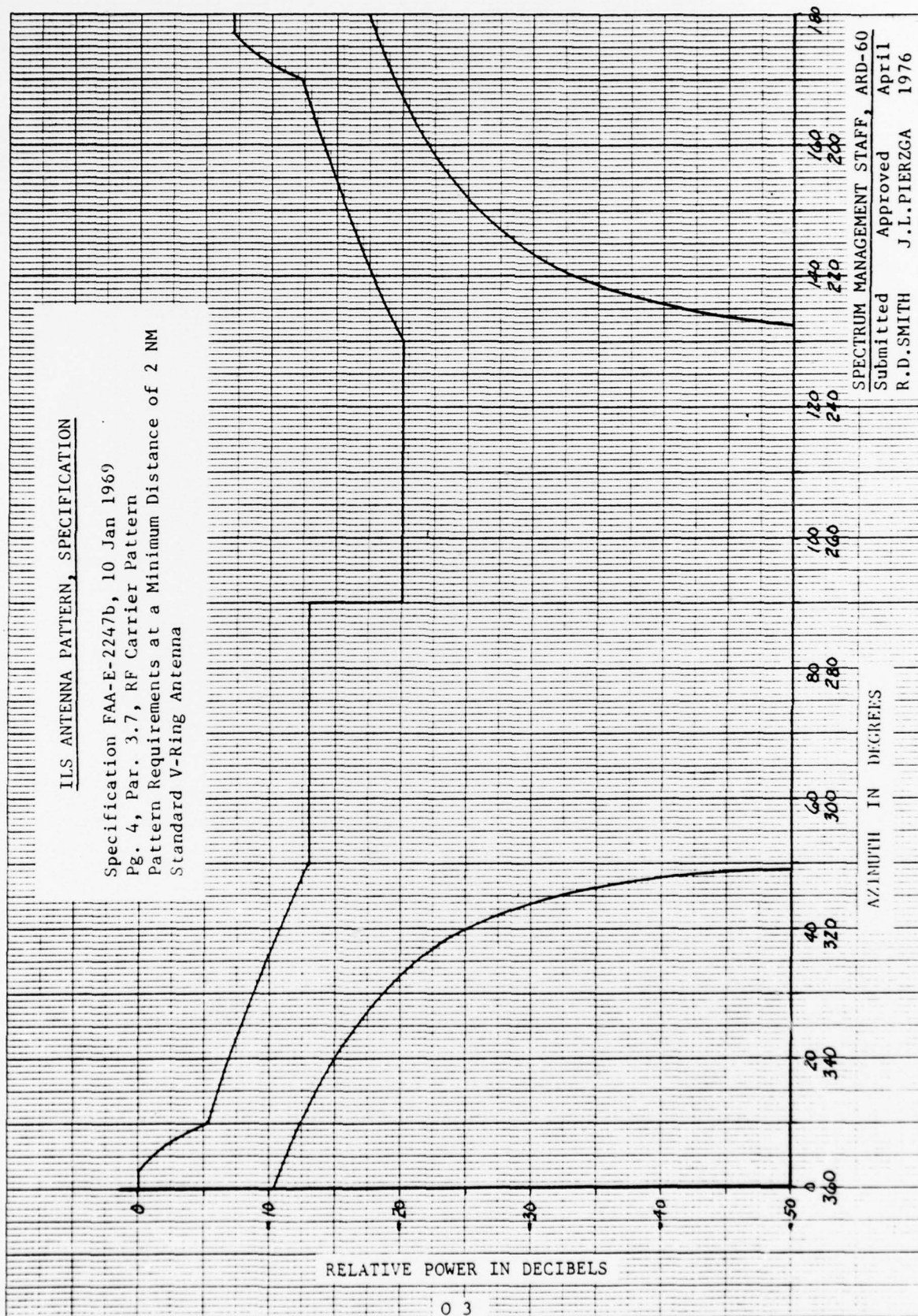
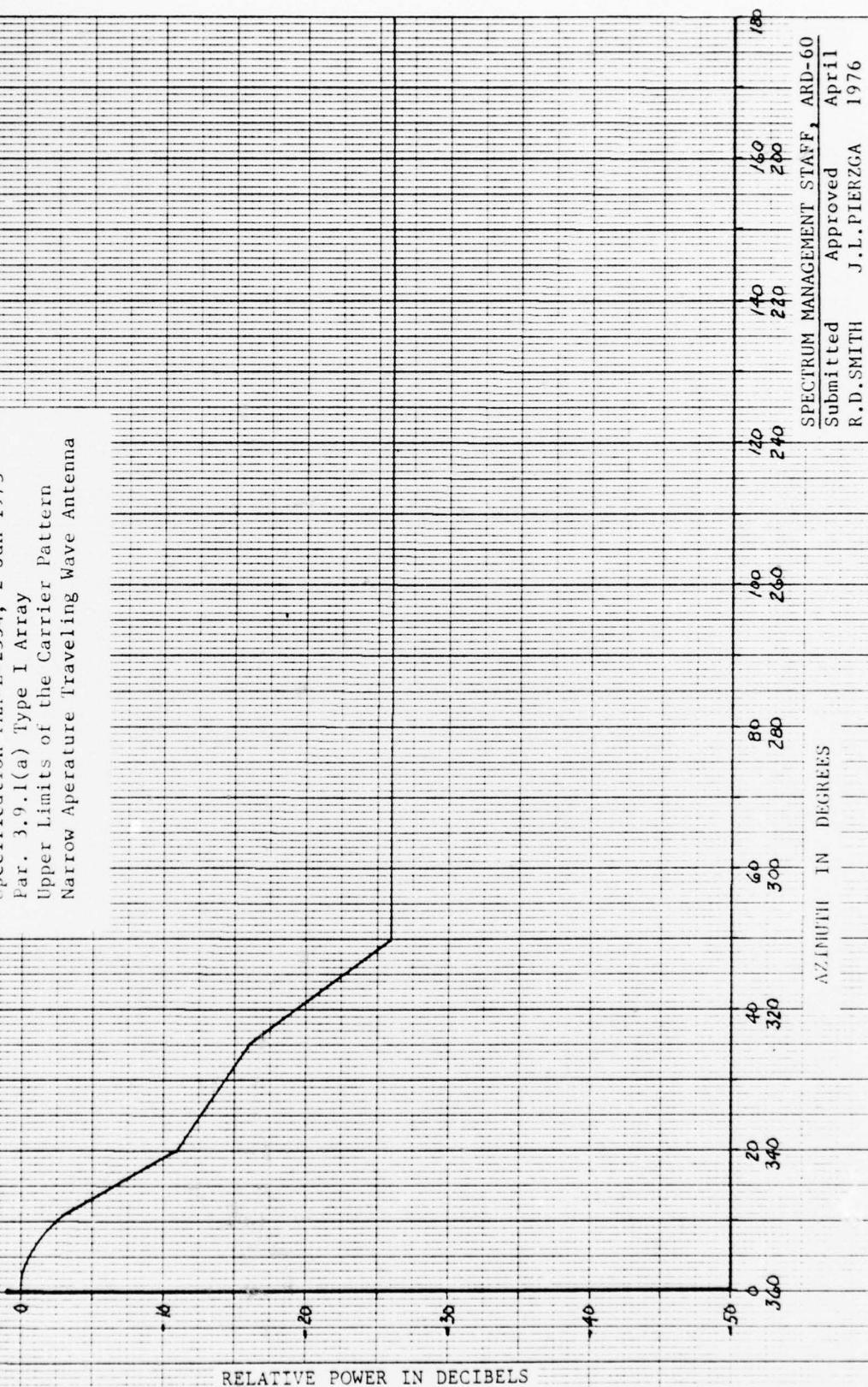


FIGURE 0 1

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April 1976

ILS ANTENNA PATTERN, SPECIFICATION

Specification FAA-E-2554, 2 Jan 1973
 Par. 3.9.1(a) Type I Array
 Upper Limits of the Carrier Pattern
 Narrow Aperture Traveling Wave Antenna

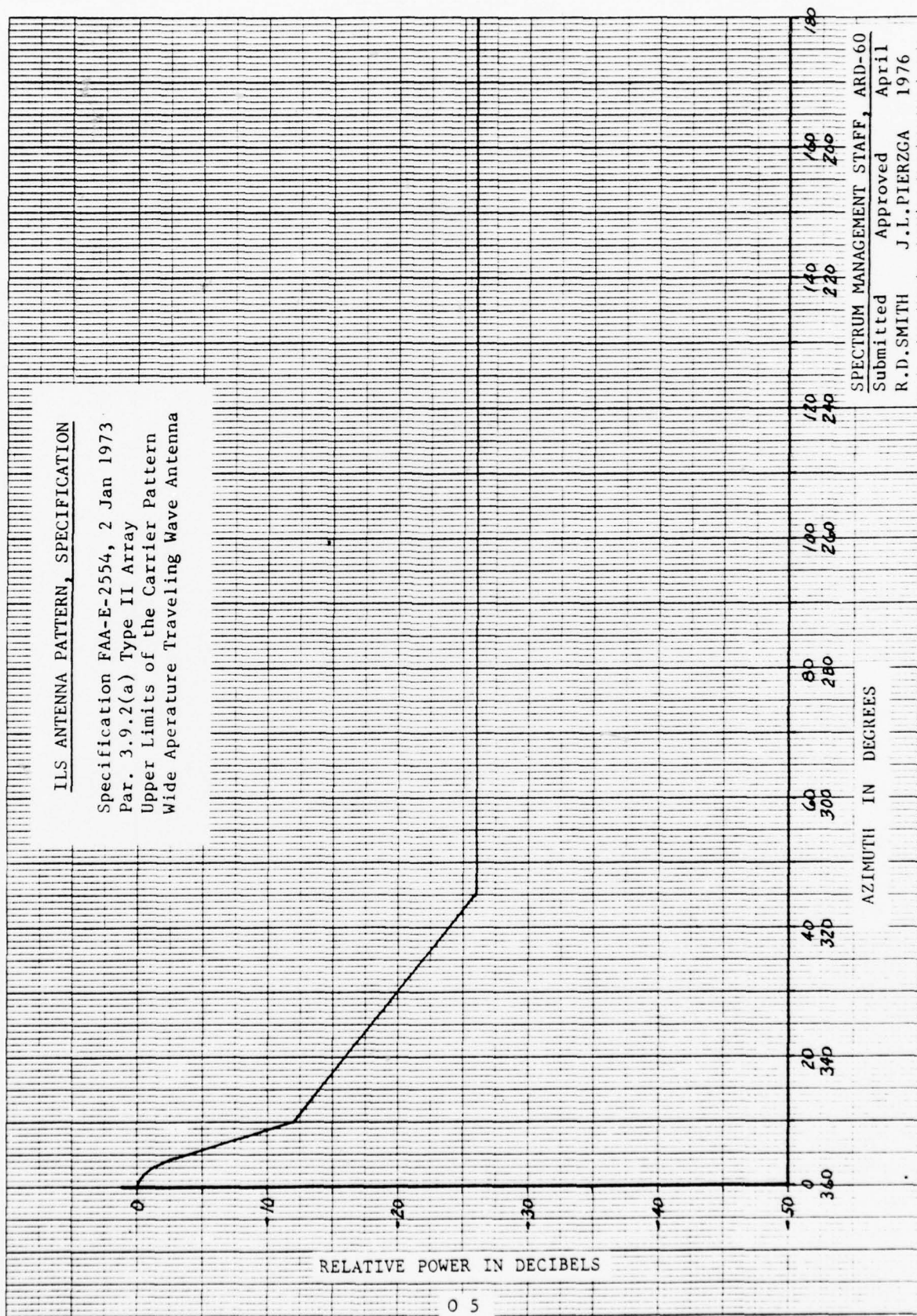


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 Submitted R.D. SMITH
 Approved J.L. PIERZGA
 April 1976

FIGURE 0 2

ILS ANTENNA PATTERN, SPECIFICATION

Specification FAA-E-2554, 2 Jan 1973
 Par. 3.9.2(a) Type II Array
 Upper Limits of the Carrier Pattern
 Wide Aperture Traveling Wave Antenna



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 Submitted R.D.SMITH
 Approved J.L.PIERZGA
 April 1976

FIGURE 0 3

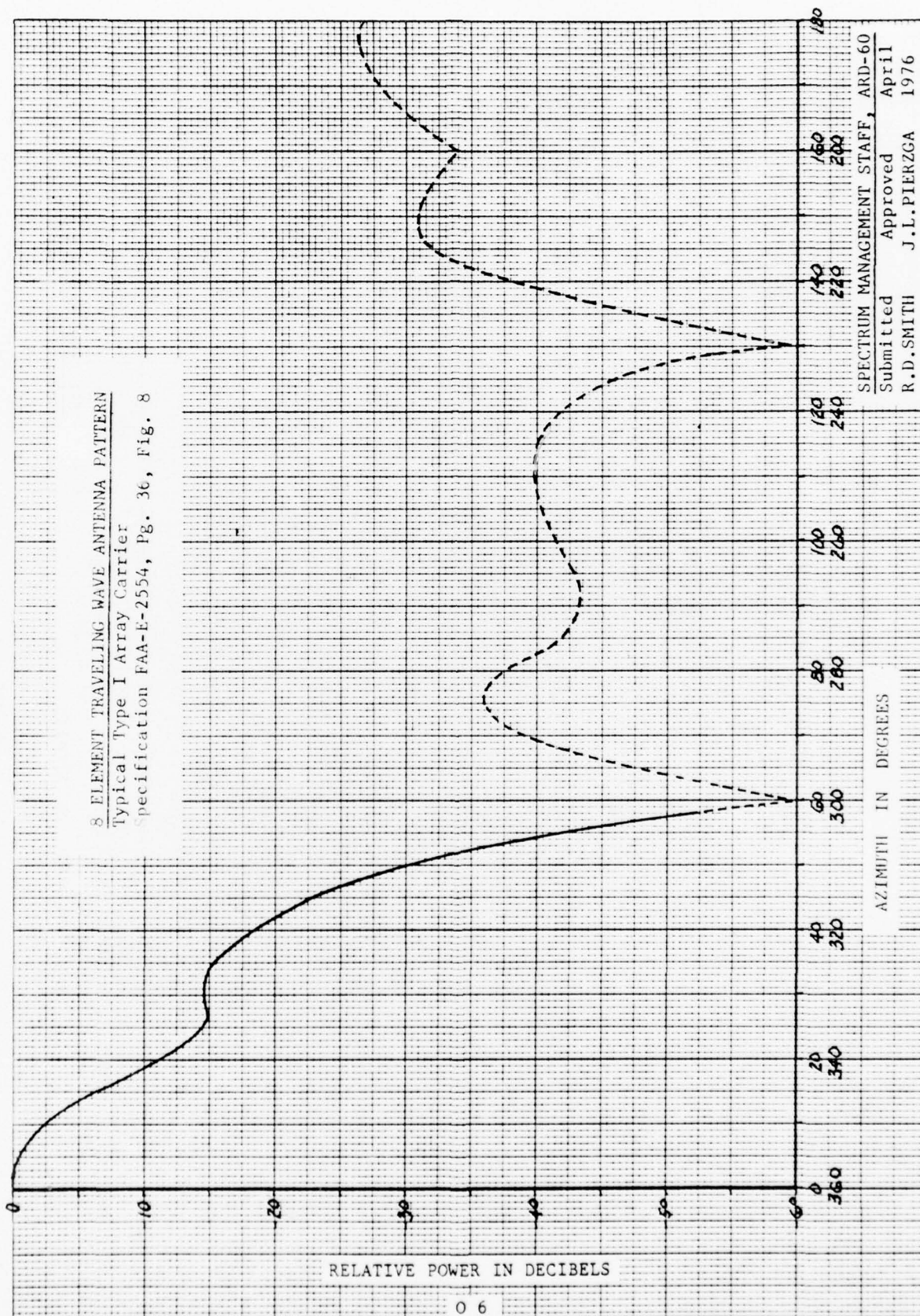


FIGURE 0 4

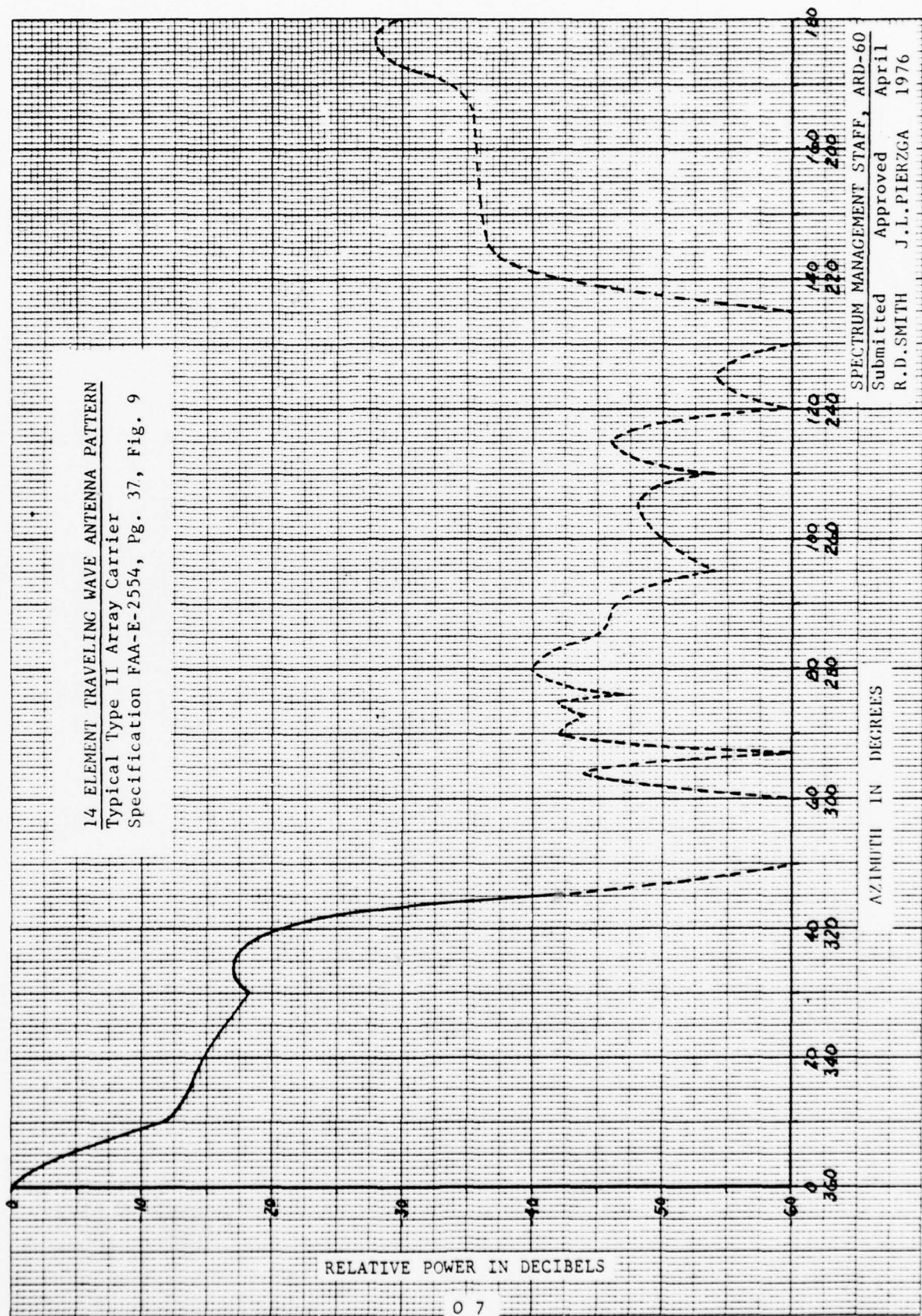


FIGURE 0 5

ILS ANTENNA PATTERN, OUTDATED SPECIFICATION

Specification FAA-E-2492/2, 14 Sept 1972
 Par. 2-3.4.3.3.1.1(a) Option 1 (Narrow Array)
 Upper and Lower Limits, Carrier Pattern
 Narrow Aperature Turnkey Specification

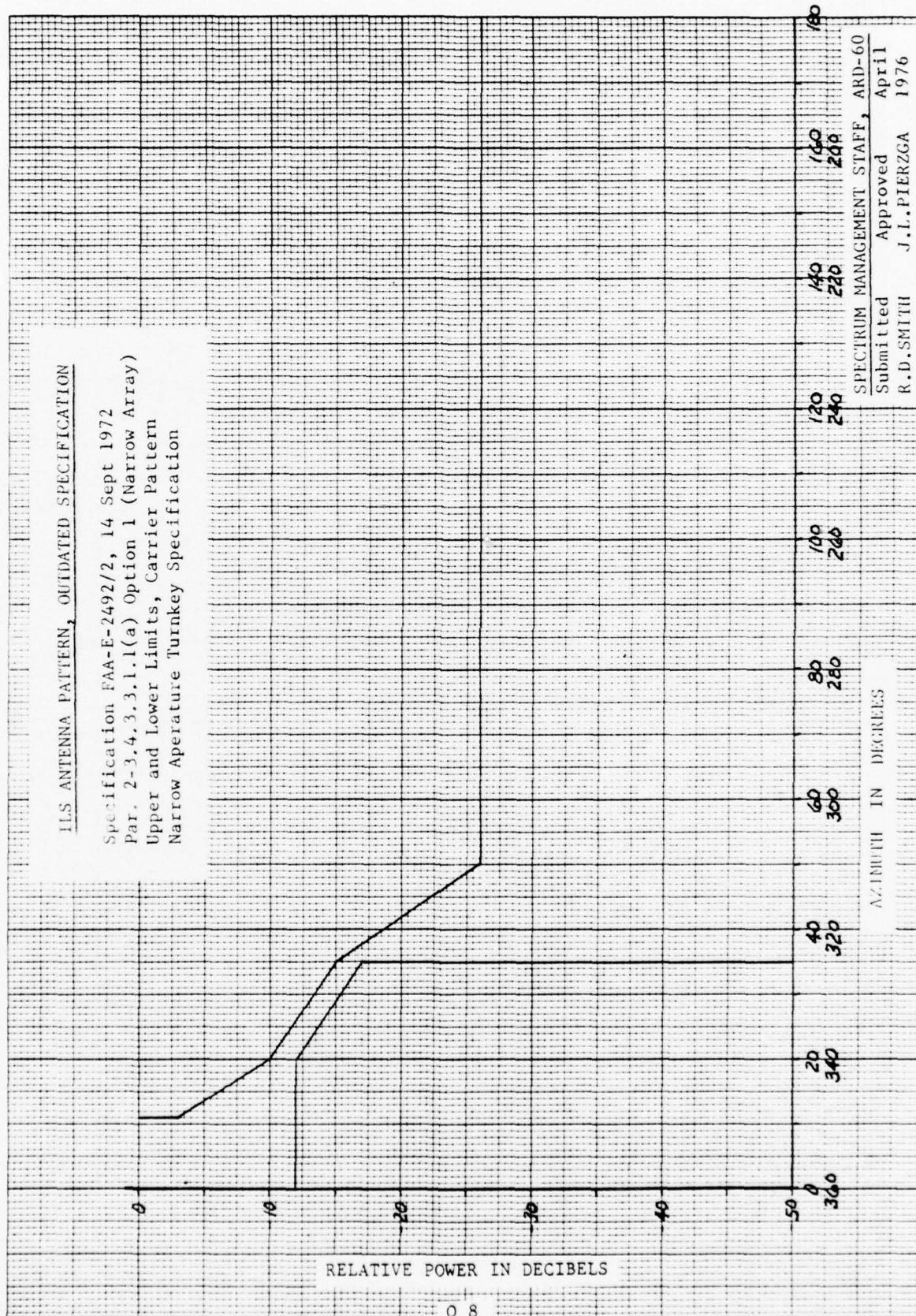
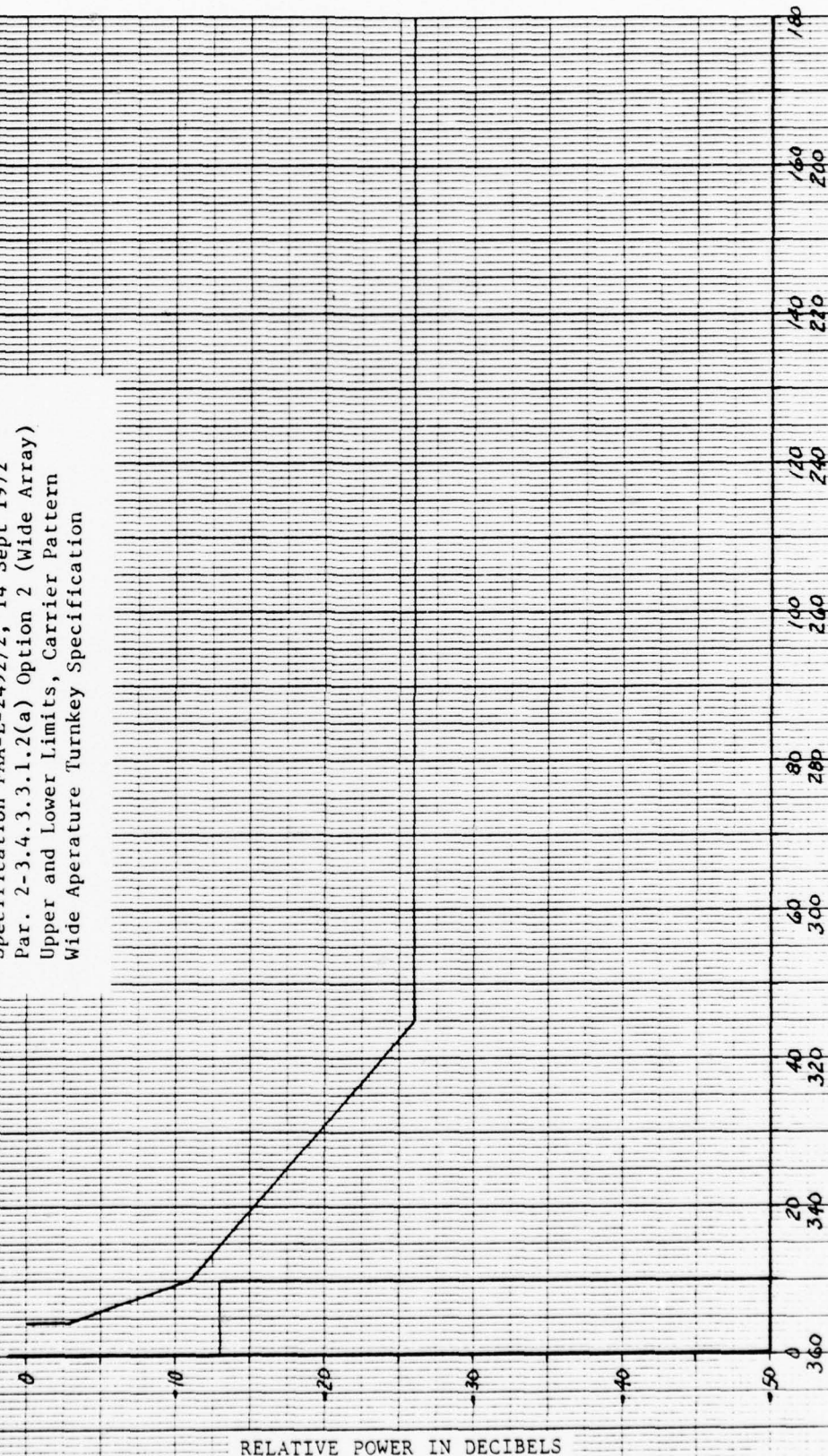


FIGURE 0 6

SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted Approved April
 R.D. SMITH J.I. PIERZGA 1976

IIS ANTENNA PATTERN, OUTDATED SPECIFICATION

Specification FAA-E-2492/2, 14 Sept 1972
 Par. 2-3.4.3.1.2(a) Option 2 (Wide Array)
 Upper and Lower Limits, Carrier Pattern
 Wide Aperature Turnkey Specification



SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted R.D.SMITH
 Approved J.L.PIERZGA
 April 1976

FIGURE O 7

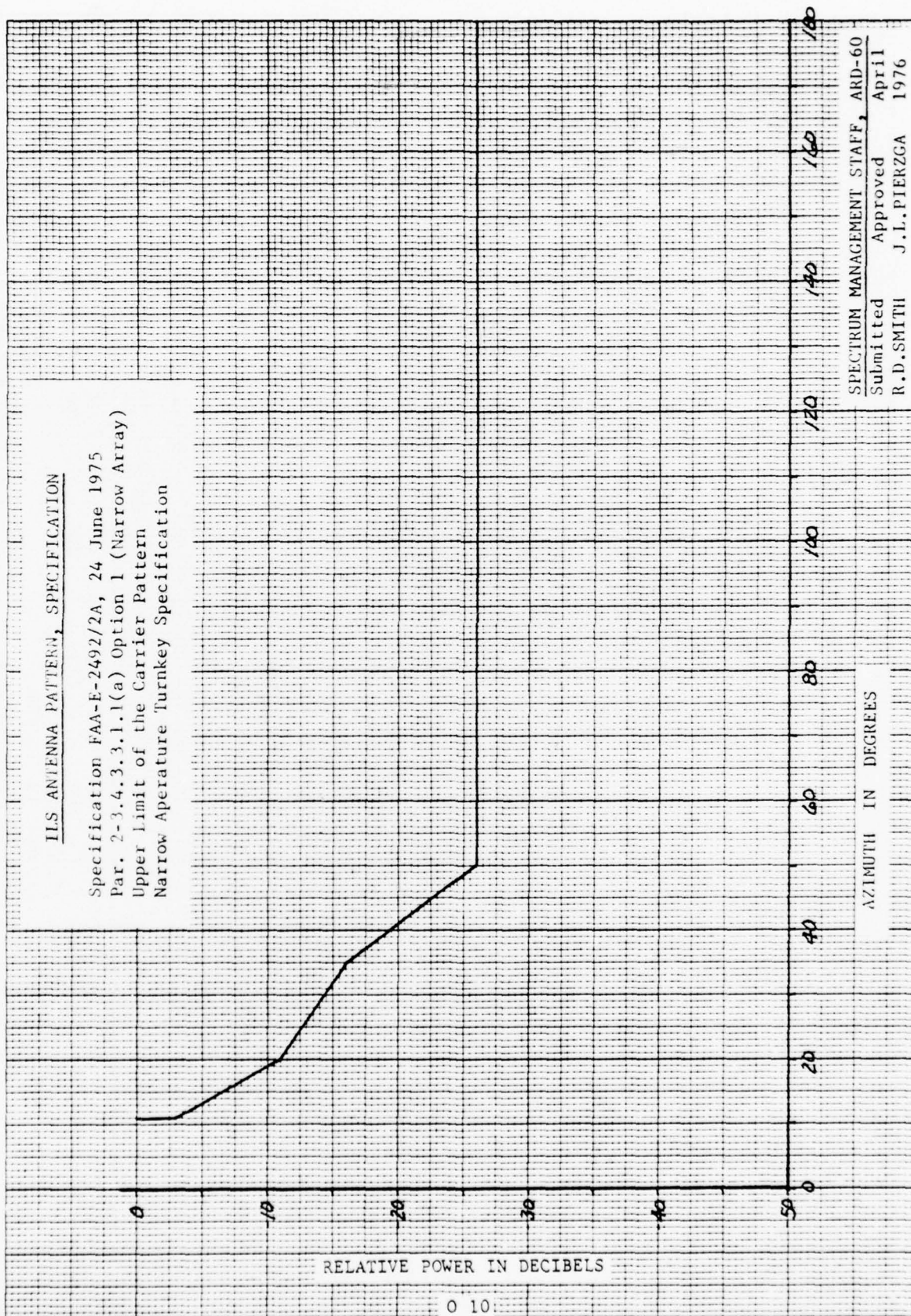
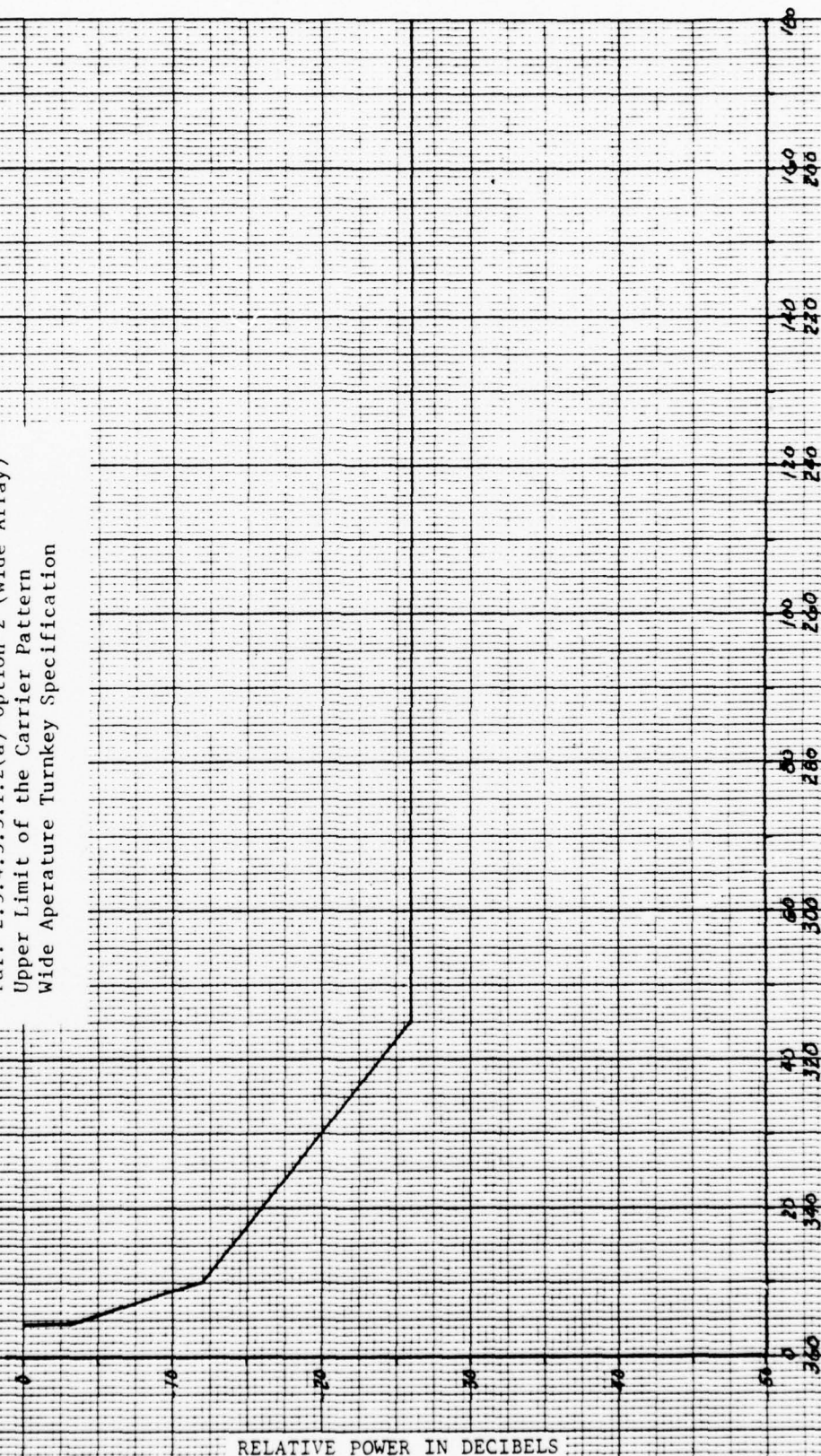


FIGURE 0 8

ILS ANTENNA PATTERN, SPECIFICATION

Specification FAA-E-2492/2A, 24 June 1975
 Par. 2.3.4.3.1.2(a) Option 2 (Wide Array)
 Upper Limit of the Carrier Pattern
 Wide Aperature Turnkey Specification



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 Submitted R.D.SMITH J.L.PIERZGA
 Approved April 1976

APPENDIX P

ADDITIONAL WILCOX ANTENNAS

In addition to the Log Periodic Dipole, a number of other Wilcox localizer antennas are in use. Among these are the following:

- A. Model 1201
- B. Model 1203
- C. Model 1204
- D. Model 1261

These antennas have not been installed at a larger number of sites and the data available on them is limited. With such a limited number of systems, a substantial measurement program is not cost effective. Additional data is not expected to become available. Conservative frequency assignment antenna patterns have been chosen after examination of the data in this Appendix and discussions with Wilcox personnel. Conservative patterns result in greater station separations for some orientations. At the same time however, they make it easier to handle these antenna type in the frequency assignment process

A. Wilcox Model 1201

This is a two frequency localizer array with 9.5 kHz between frequencies. The course array consists of 18 half-wave dipoles arranged as nine pairs with nine reflector sections. The dipoles are enclosed in T-shaped circular tubes. The array is 88 feet long. The top of the reflectors are normally seven or eight feet above ground. The dipoles themselves are therefore five or six feet above ground. The clearance array consists of five slot antennas. It is 15 feet wide and is placed approximately 75 feet behind the main array. The clearance pattern is omnidirectional.

A small number of Model 1201 systems have been installed. Among them are the systems at Palmdale, Calif. and Spirit of St. Louis, Mo.

B. Wilcox Model 1203

This is a single frequency, log periodic dipole array. It is composed of six LPD elements, non uniformly spaced. In the U.S., only a few of this system have been installed. One is located at Gary, Ind., another at Indiana County Pa. This antenna uses elements purchased from NERA in Oslo, Norway (NERA System XAII). Some locations use elements with a 30 dB front to back ratio. Others use elements with a 14 dB front to back ratio. This results in front to back ratios of 20 dB and 12 dB for the antenna arrays. Since it will be difficult or impossible to determine which antenna elements went to which locations, the more conservative 12 dB front to back ratio has been assumed for all antennas of this nomenclature.

C. Wilcox Model 1204

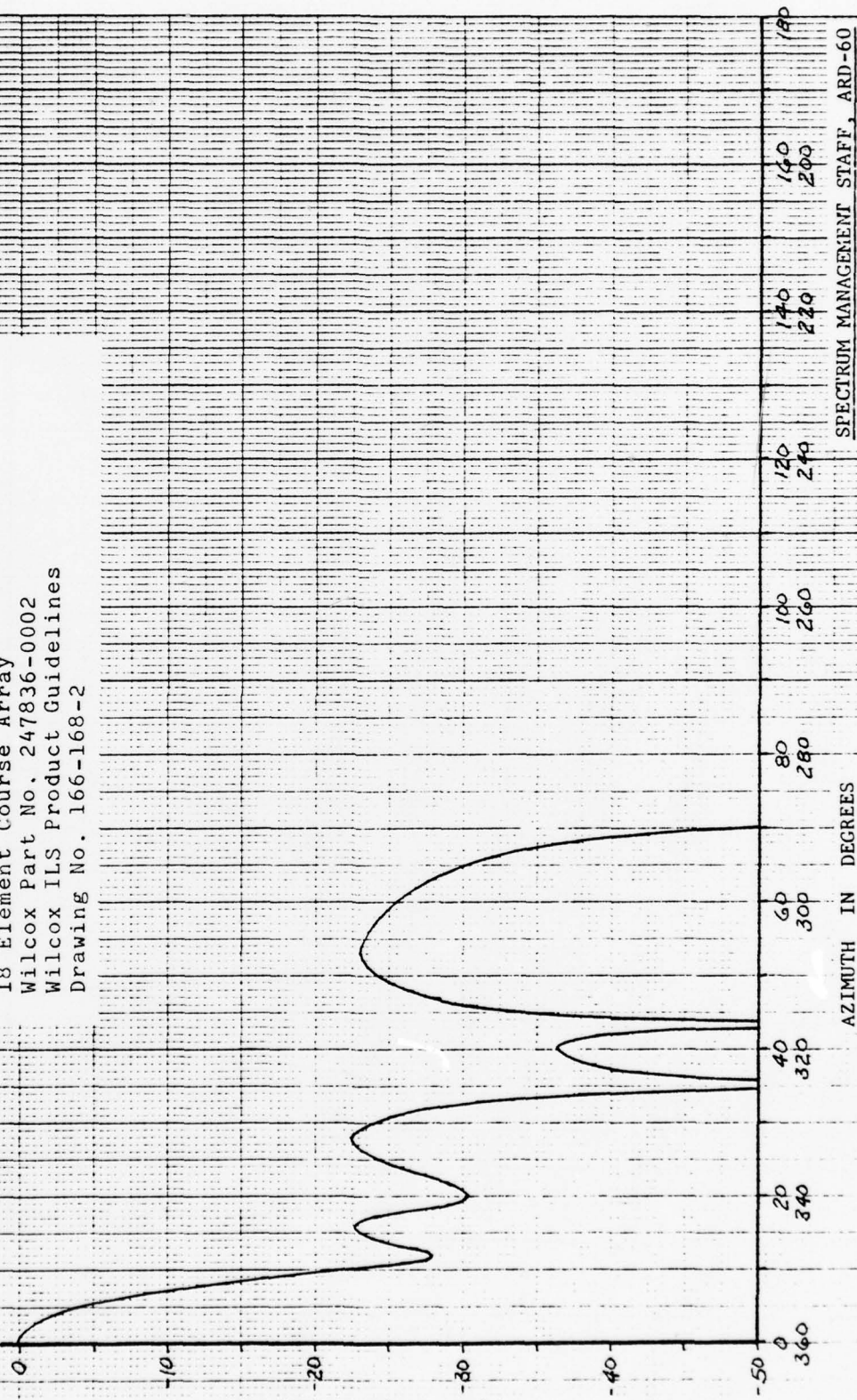
This is a single frequency array composed of 16 half-wave dipole elements arranged as eight pairs with eight reflector sections. The elements are similar to the course elements of the model 1201. The only Model 1204 installation is at Somerset, Pa. No others are anticipated.

D. Wilcox Model 1261

This is a single frequency array composed of six half-wave dipole elements, each with a parasitic reflector rod. At present, the only installation of this antenna is at Greenville, Texas. Wilcox anticipates additional non-federal systems will be installed with this antenna in the future, however. The data in this Appendix was obtained the manufacturer (Reference 28). Measured data on these antennas would be helpful. With the low number of systems involved, it is unlikely that this data will become available unless it can be collected during a routine flight check.

MODEL 1201 DUAL FREQUENCY LOCALIZER ANTENNA
THEORETICAL ANTENNA PATTERN

18 Element Course Array
Wilcox Part No. 247836-0002
Wilcox ILS Product Guidelines
Drawing No. 166-168-2



SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted R.D. Smith
Approved J.L. Pierzga
June 1977

FIGURE P 1

MODEL 1201 DUAL FREQUENCY LOCALIZER ANTENNA
THEORETICAL ANTENNA PATTERN

18 Element Course Array
 Wilcox Part No. 247836-0002
 Wilcox Instruction Manual 504970-0300
 15 March 1971, Page 3-7, Figure 3-6

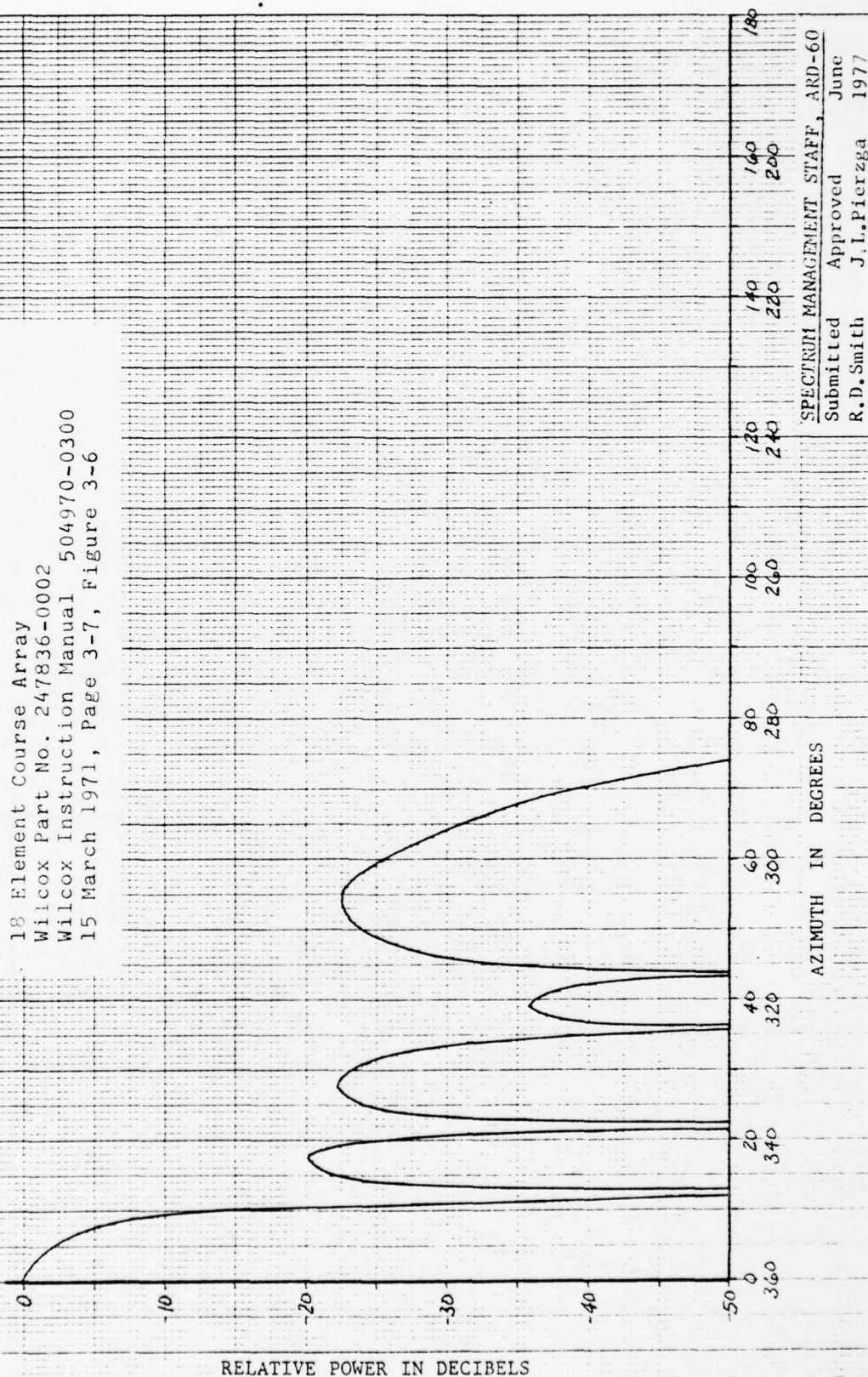
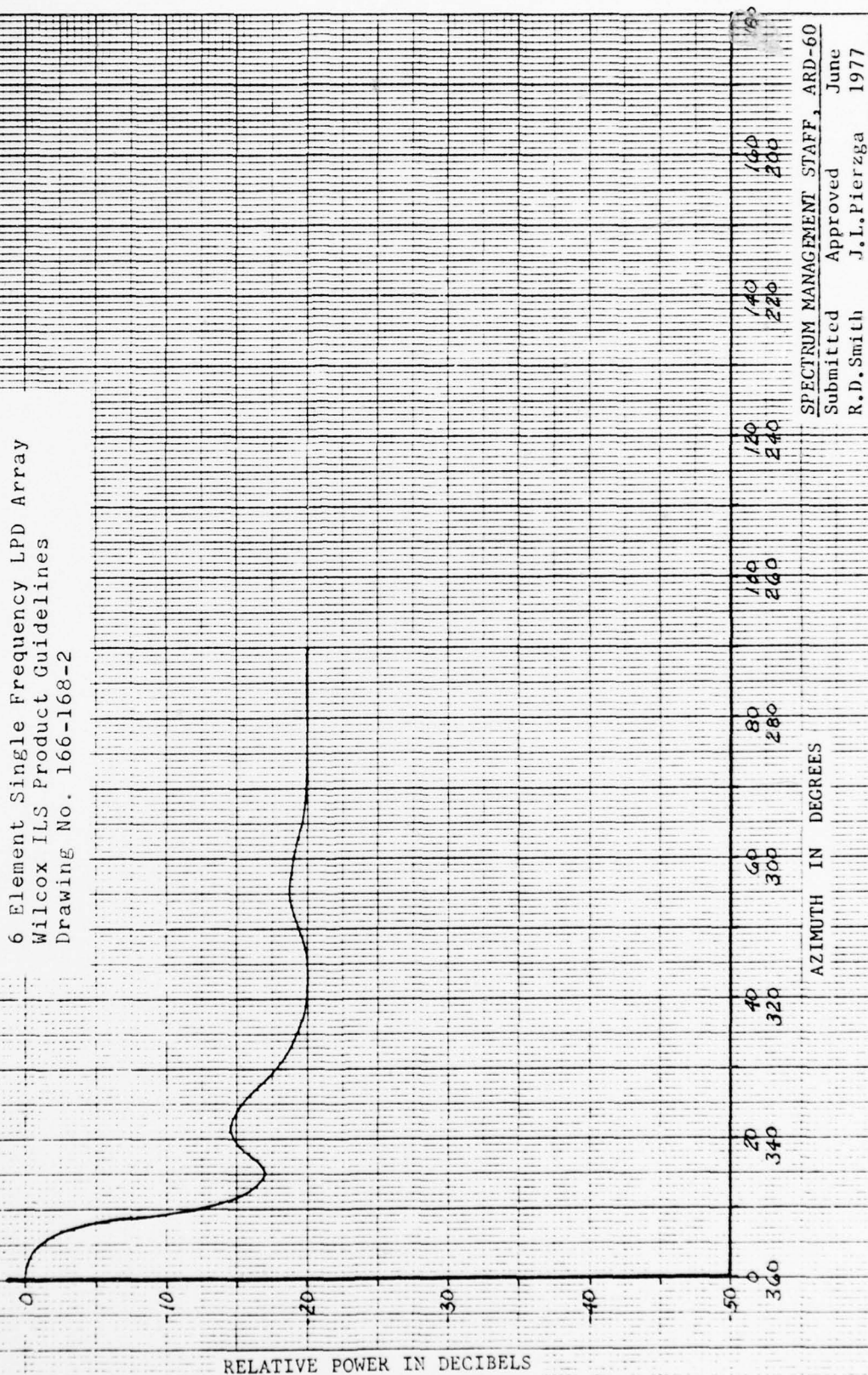


FIGURE P 2

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 Approved J.L. Pierzga
 June 1977

WILCOX MODEL 1203, LOG PERIODIC DIPOLE
THEORETICAL ANTENNA PATTERN

6 Element Single Frequency LPD Array
 Wilcox ILS Product Guidelines
 Drawing No. 166-168-2

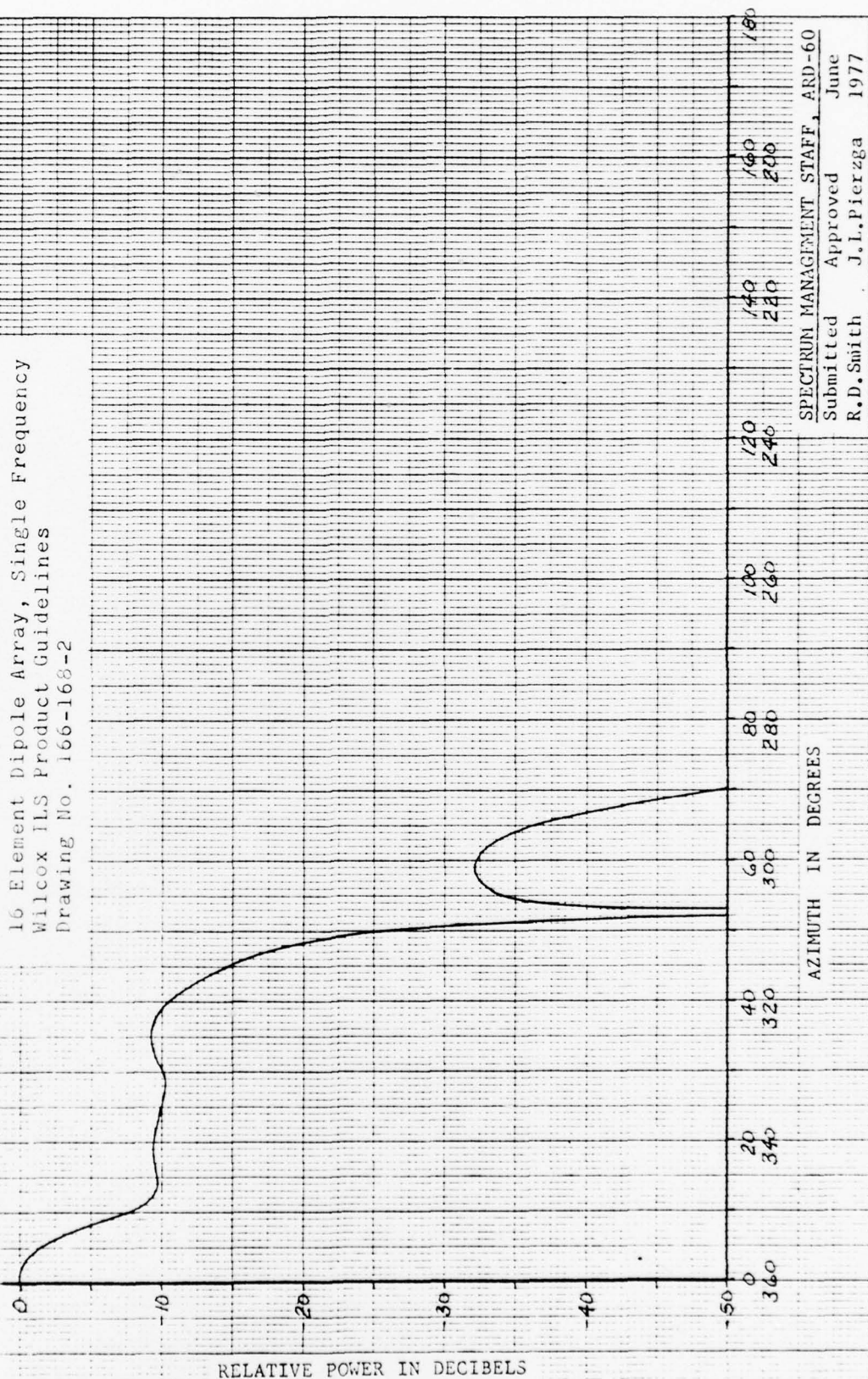


SPECTRUM MANAGEMENT STAFF, ARD-60
 Submitted Approved June
 R.D. Smith J.L. Pierzga 1977

FIGURE P 3

WILCOX MODEL 1204, COLINEAR DIPOLE
THEORETICAL ANTENNA PATTERN

16 Element Dipole Array, Single Frequency
Wilcox ILS Product Guidelines
Drawing No. 166-168-2

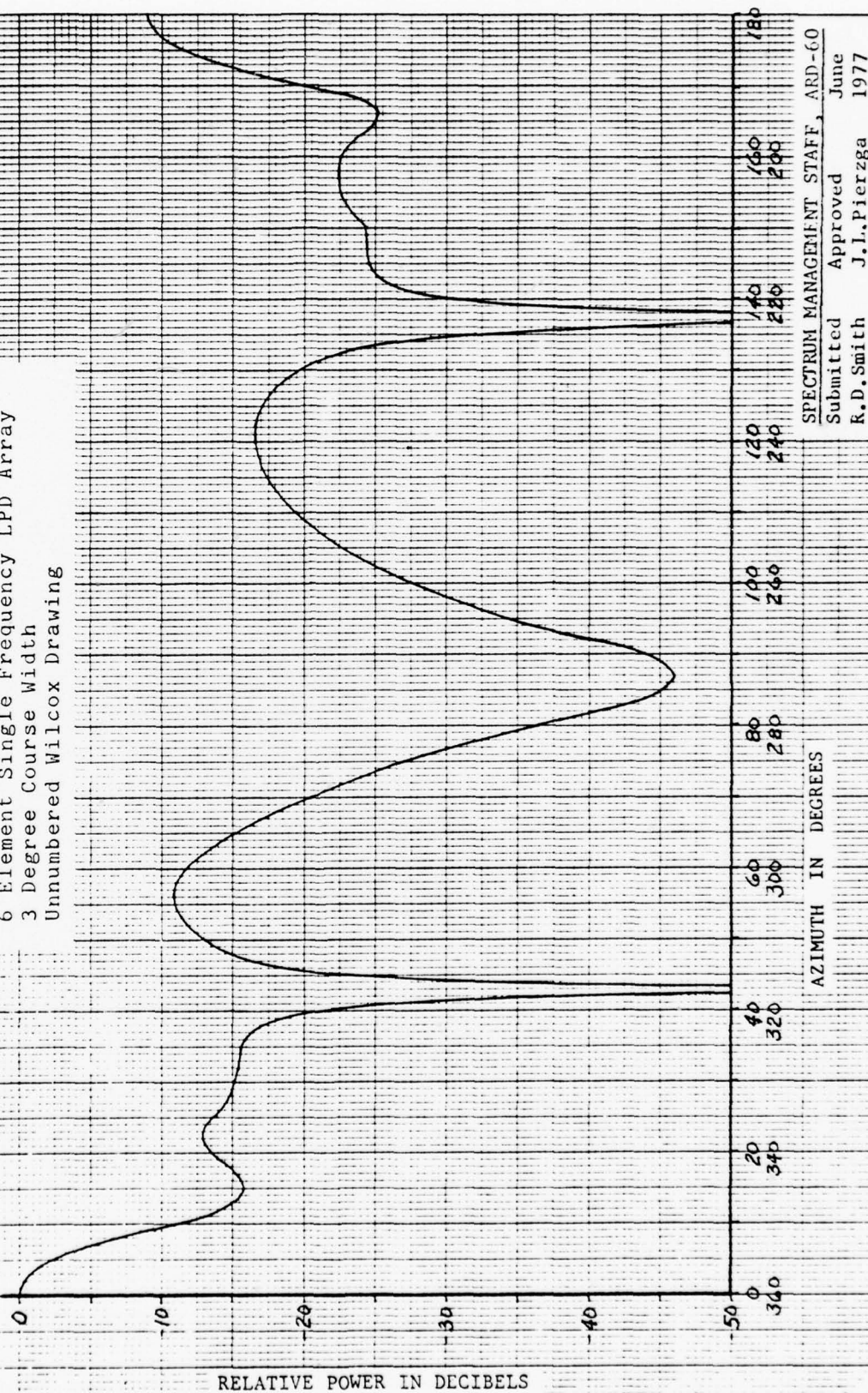


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Submitted R.D. Smith
Approved J.L. Pierzga
June 1977

FIGURE P 4

WILCOX MODEL 1261, LOG PERIODIC DIPOLE
THEORETICAL ANTENNA PATTERN

6 Element Single Frequency LPD Array
 3 Degree Course Width
 Unnumbered Wilcox Drawing

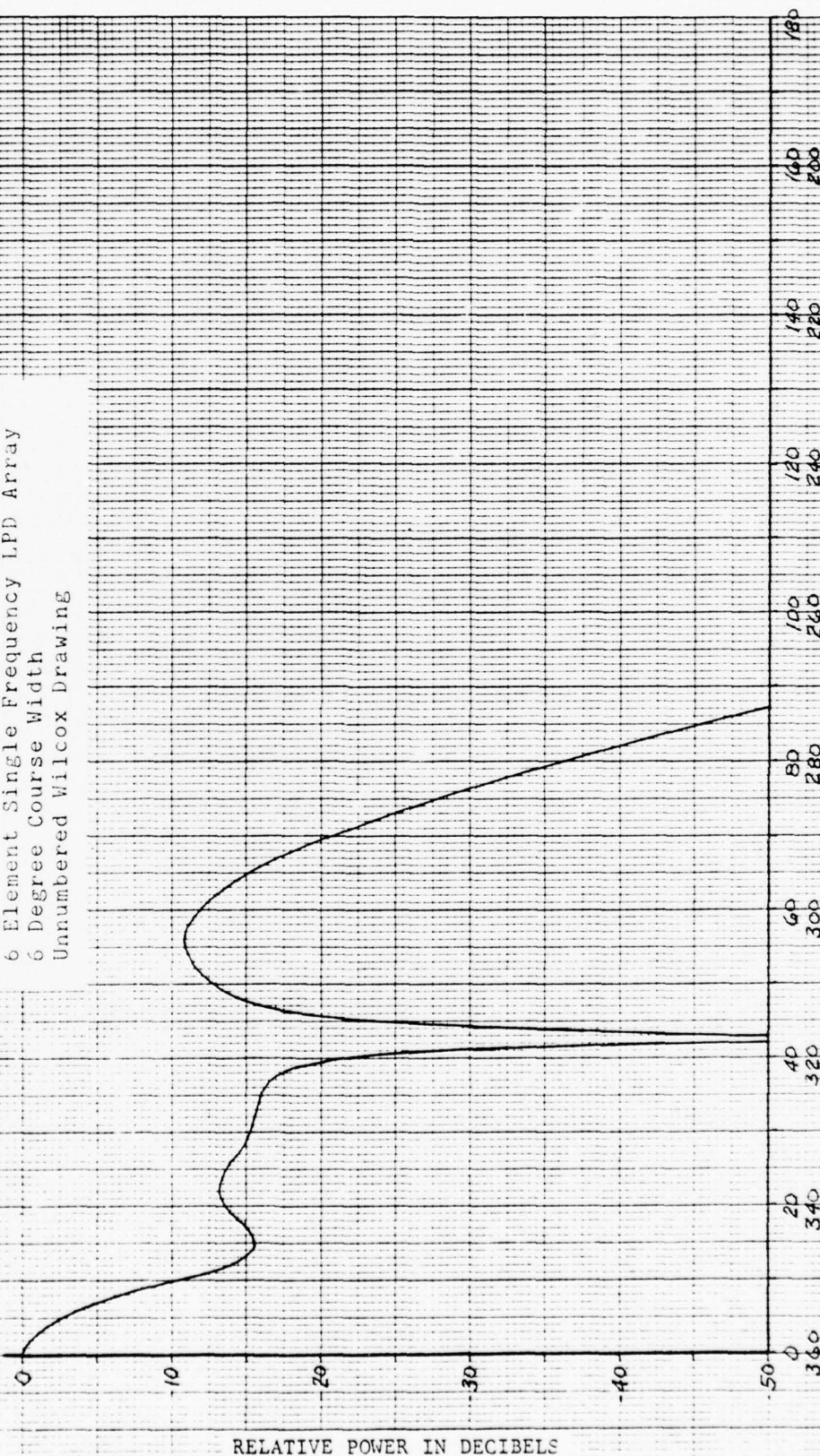


SPECTRUM MANAGEMENT STAFF, ARD-60
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 Approved J.L. Pierzga
 June 1977

FIGURE P 5

WILCOX MODEL 1261, LOG PERIODIC DIPOLE
THEORETICAL ANTENNA PATTERN

6 Element Single Frequency LPD Array
6 Degree Course Width
Unnumbered Wilcox Drawing



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June 1977

FIGURE P 6

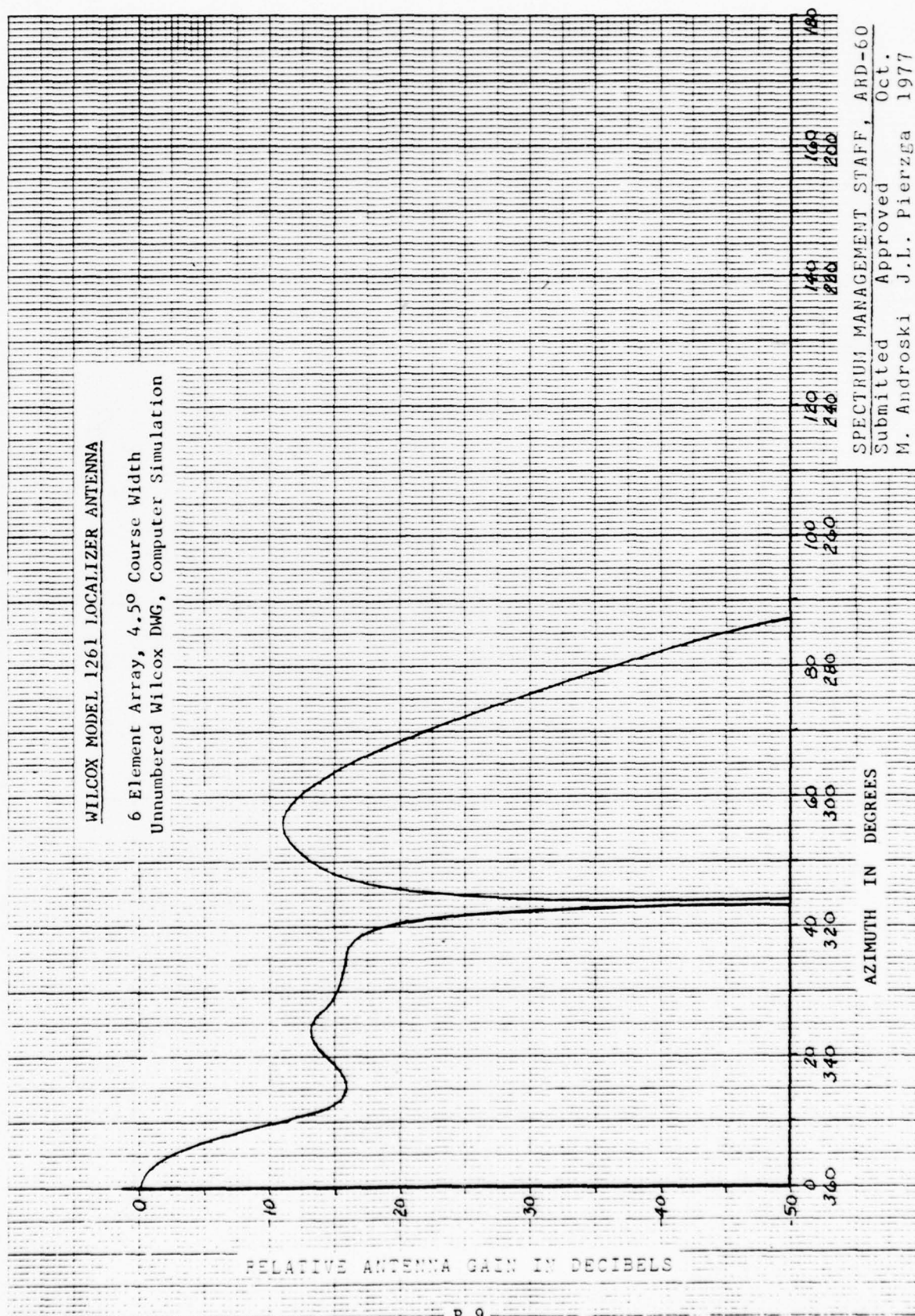


FIGURE P 7

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 Submitted Approved Oct.
 M. Androski J.L. Pierzga 1977

WILCOX MODEL 1261 LOCALIZER ANTENNA

6 Element Array, 6.0° Course Width
Unnumbered Wilcox DWG, Computer Simulation

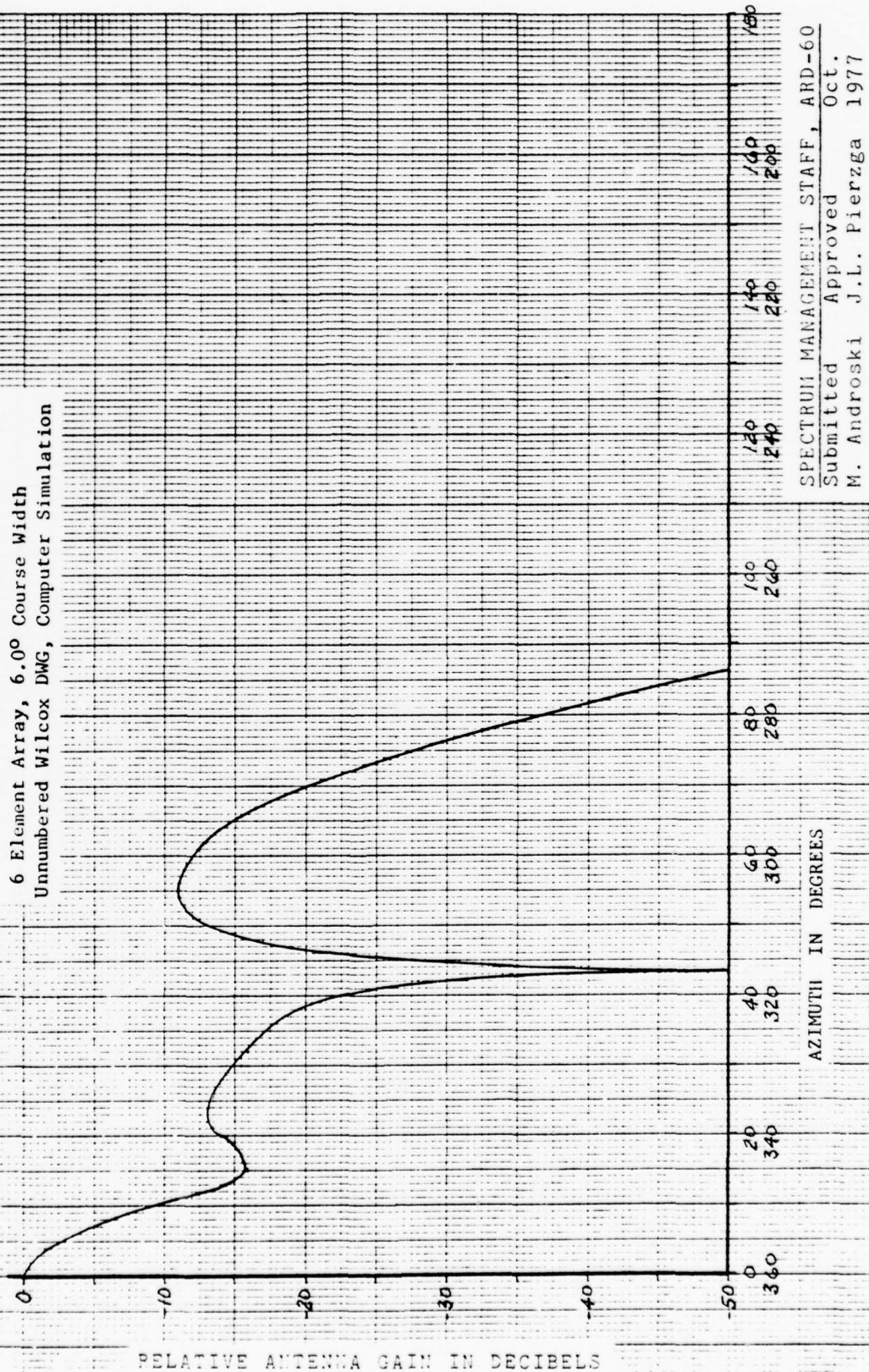
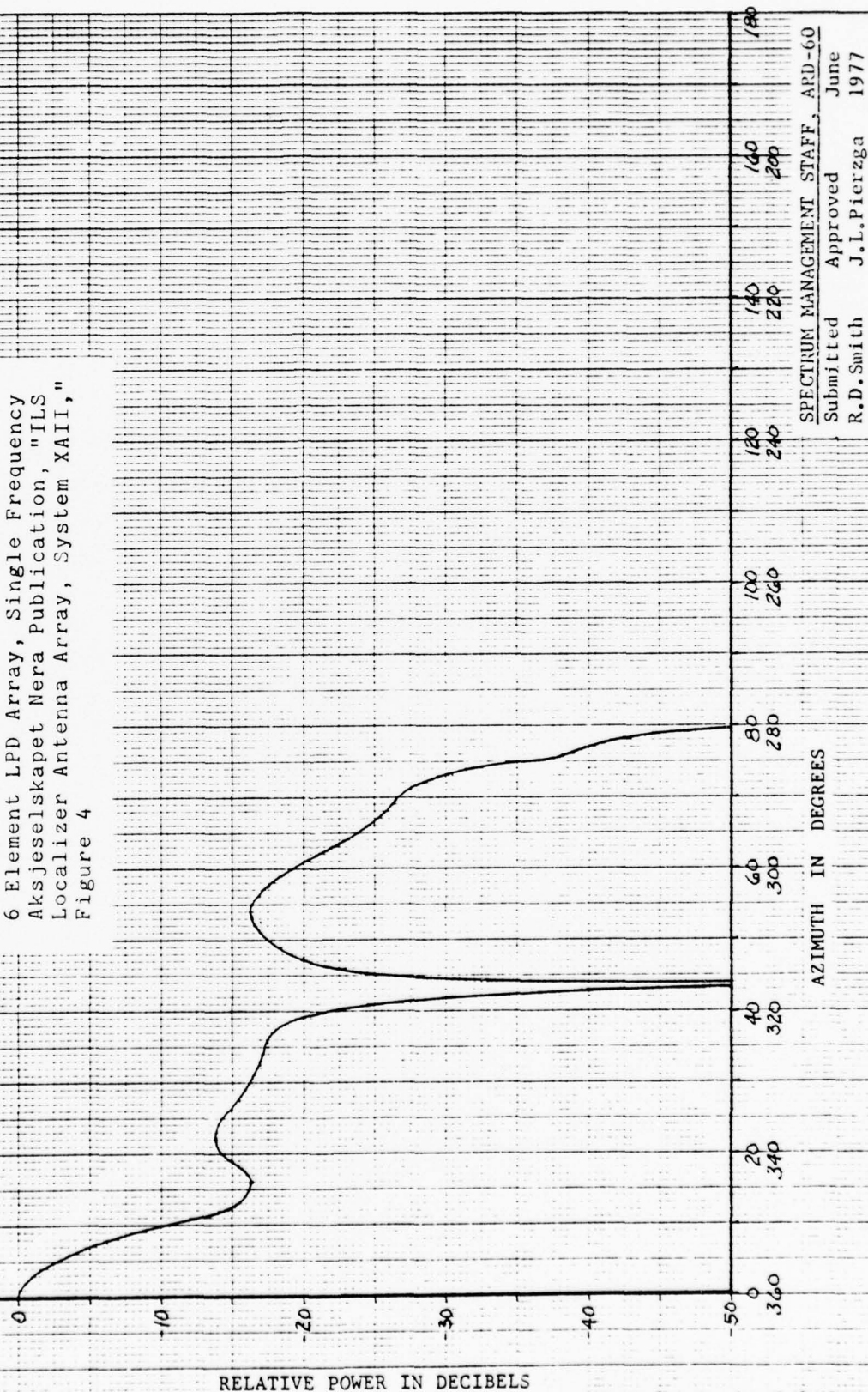


FIGURE P 8

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Submitted Approved Oct.
M. Androski J.L. Pierzga 1977

NERA SYSTEM XAII, LOG PERIODIC DIPOLE
THEORETICAL ANTENNA PATTERN

6 Element LPD Array, Single Frequency
Aksjeselskapet Nera Publication, "ILS
Localizer Antenna Array, System XAII,"
Figure 4



SPECTRUM MANAGEMENT STAFF, ARD-60
Submitted R.D. Smith
Approved J.L. Pierzga
June 1977

FIGURE P 9

APPENDIX Q

PICTURES OF ILS LOCALIZER ANTENNAS

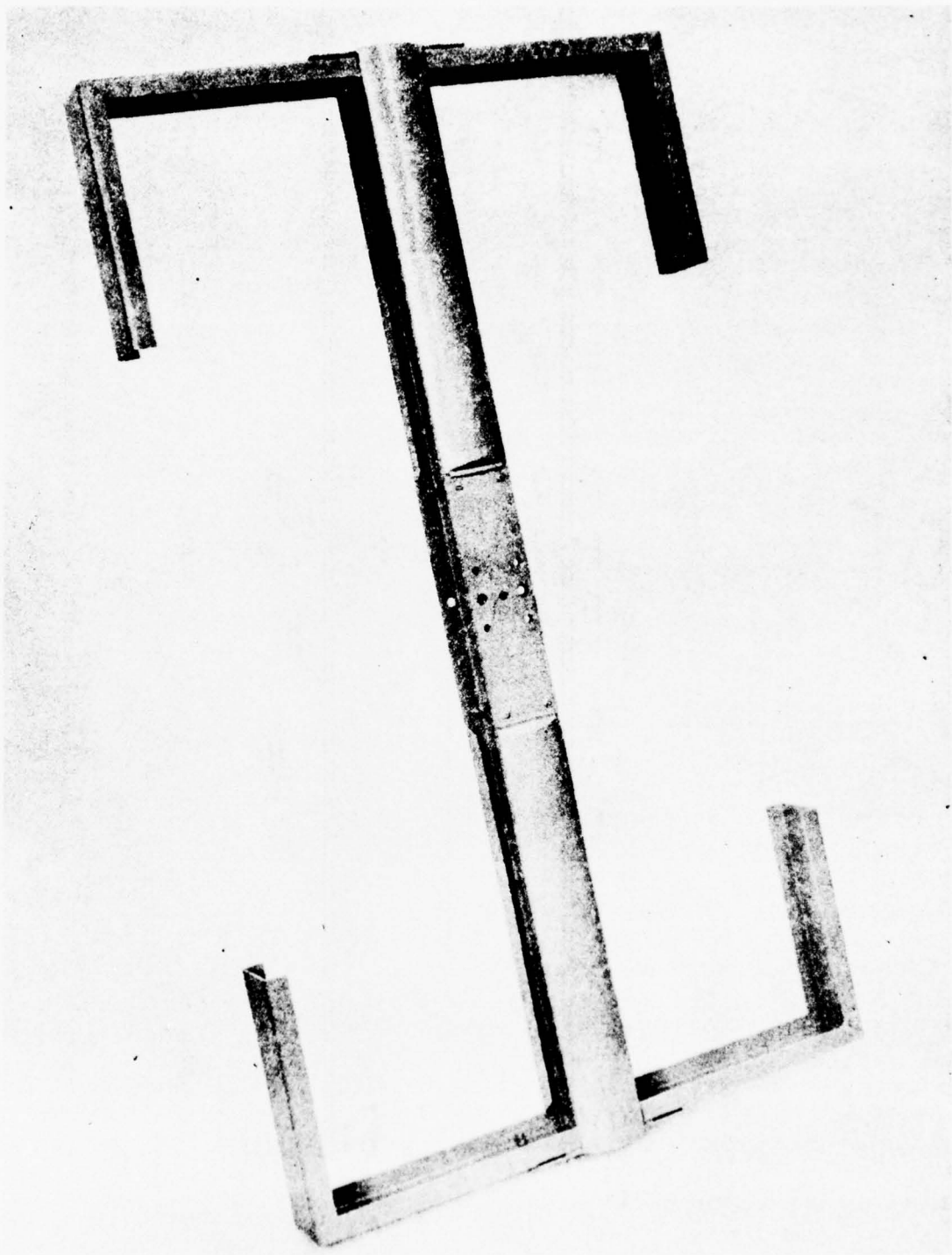
Different types of localizer antennas have substantially different antenna patterns. These differences should be considered in the frequency assignment process. Consideration requires knowledge of the desired and undesired stations' antenna types. FAA sector offices provide this information to the Electromagnetic Compatibility Analysis Center (ECAC). FAA has an interagency agreement with ECAC. The FAA provides to ECAC, data on telecommunication systems. ECAC does the record keeping and provides to FAA, computer printouts upon request. For the frequency assignment process, the Frequency Management Officer (FMO) may choose to use the ECAC records or he may contact the FAA sector offices directly. In either case, the identification of the antenna type comes from the FAA sector maintenance office. Since this is the case, sector personnel should be capable of identifying the different antenna types. With the many different localizer antenna types, this can be a difficult assignment. FAA type numbers are helpful but they have not been assigned to all antenna types. In many cases, visual identification is essential. Since, to our knowledge, no single FAA publication shows all localizer antenna types, this appendix has been an attempt to do that.



A.I.L. 9 Element Twin Tee Array, Type 352110
Photo Courtesy Airborne Instruments Laboratory (A.I.L.)

FIGURE Q 1

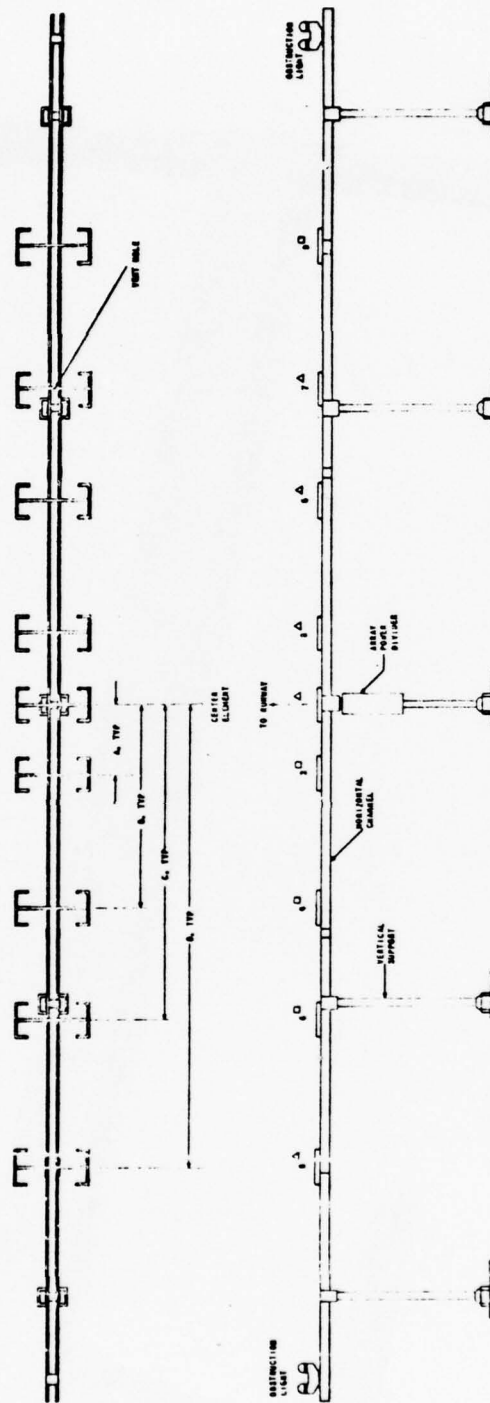
Q 2



Single A.I.L. Twin Tee Element, Type 352111-1
Photo Courtesy Airborne Instruments Laboratory (A.I.L.)

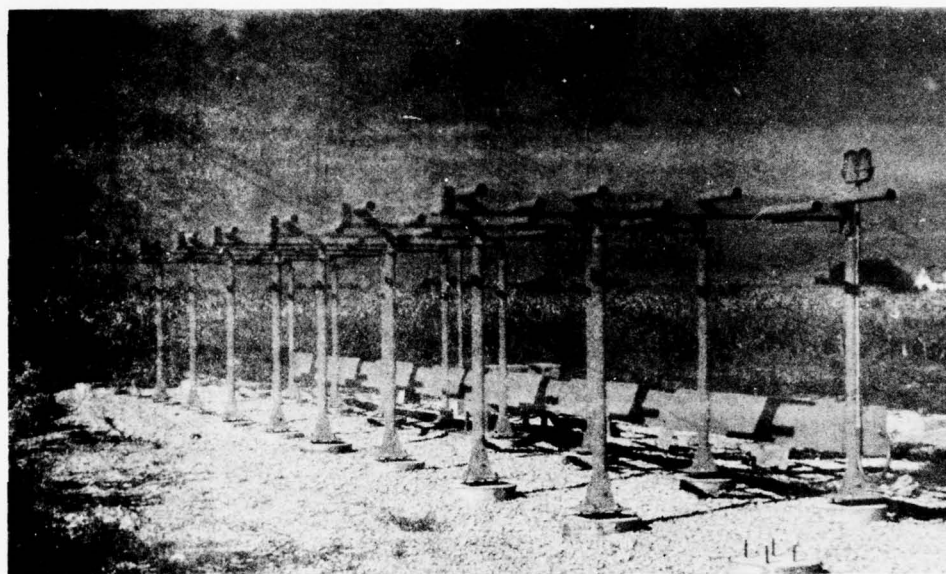
FIGURE Q 2

Q 3



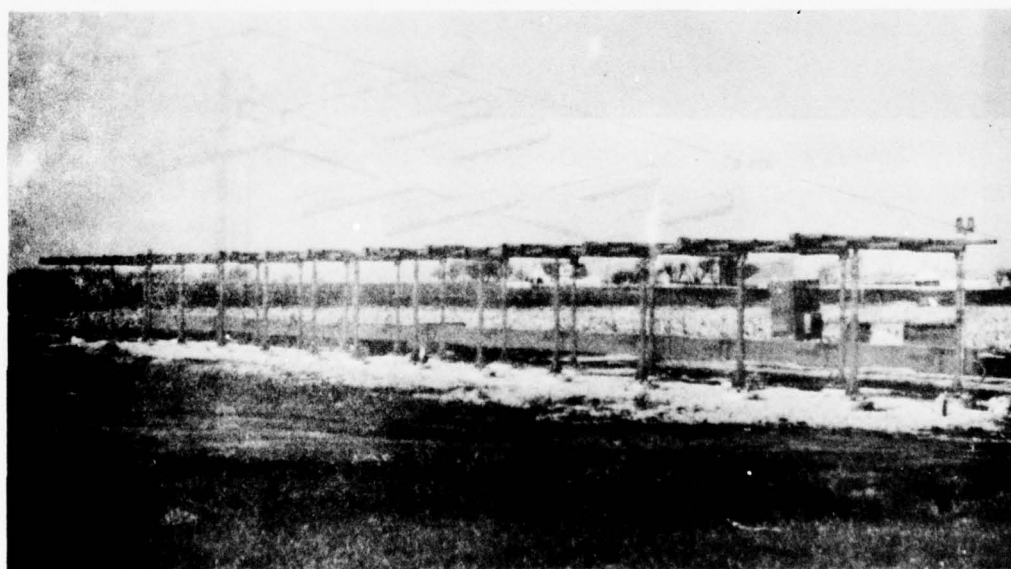
A.I.L. 9 Element Twin Tee Localizer Array
Type 352110 (Top View and Front View)

FIGURE Q 3



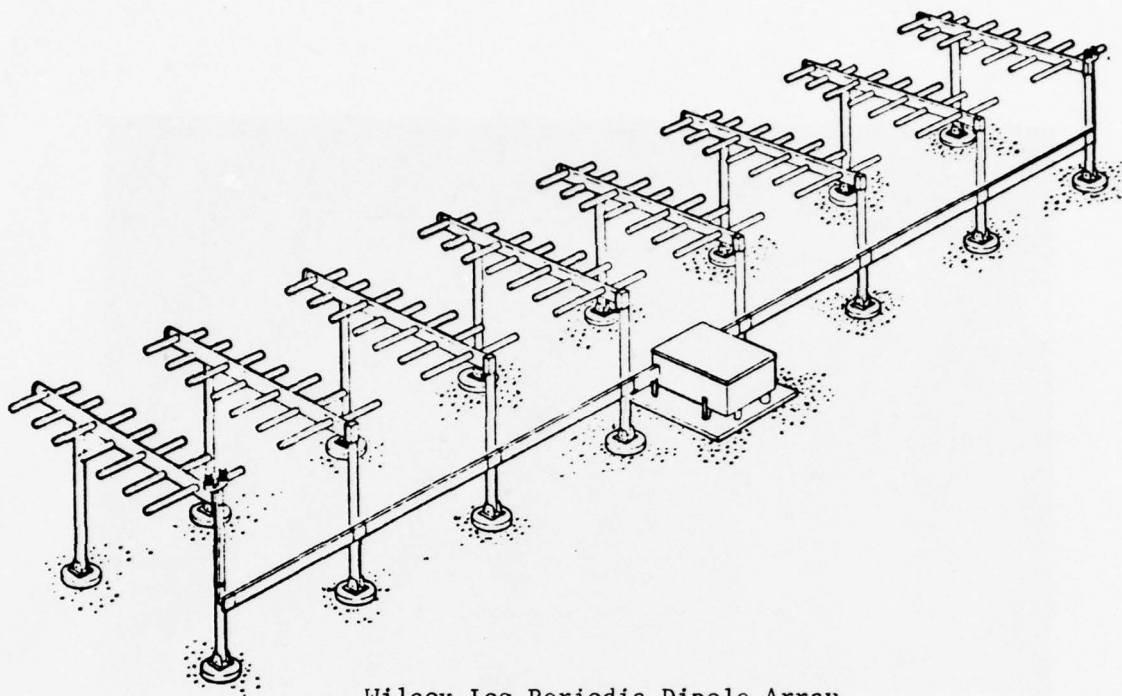
Log Periodic Dipole Localizer Antenna Array
Wilcox Mark 1D (8 Elements), Higginsville, Mo.

Photo Courtesy Wilcox Electric Incorporated
FIGURE Q 4



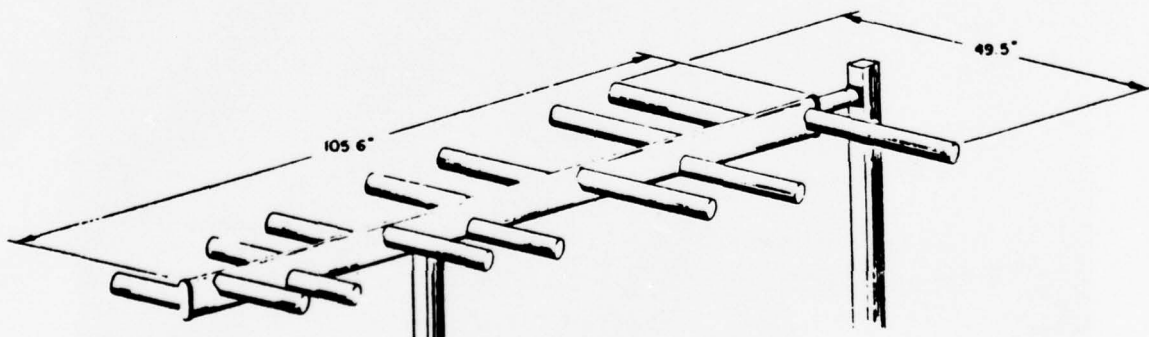
Log Periodic Dipole Localizer Antenna Array
Wilcox Mark 1D (14 Elements), Higginsville, Mo.

Photos Courtesy Wilcox Electric Incorporated
FIGURE Q 5



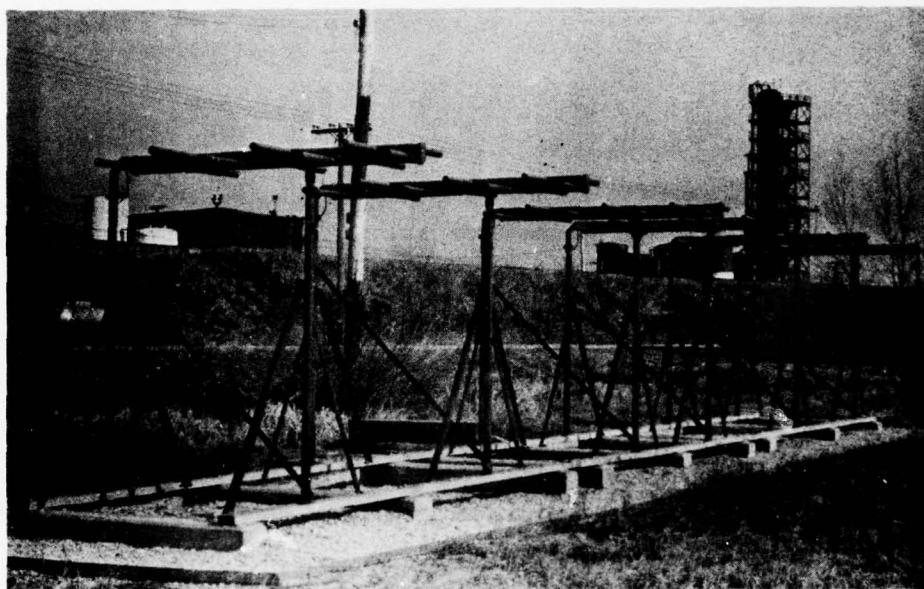
Wilcox Log Periodic Dipole Array

FIGURE Q 6



Single Wilcox Log Periodic Dipole Element

FIGURE Q 7



Log Periodic Dipole Localizer Antenna Array
Wilcox Model 1203 (6 Elements), Gary, Ind.

Photos Courtesy Wilcox Electric Incorporated

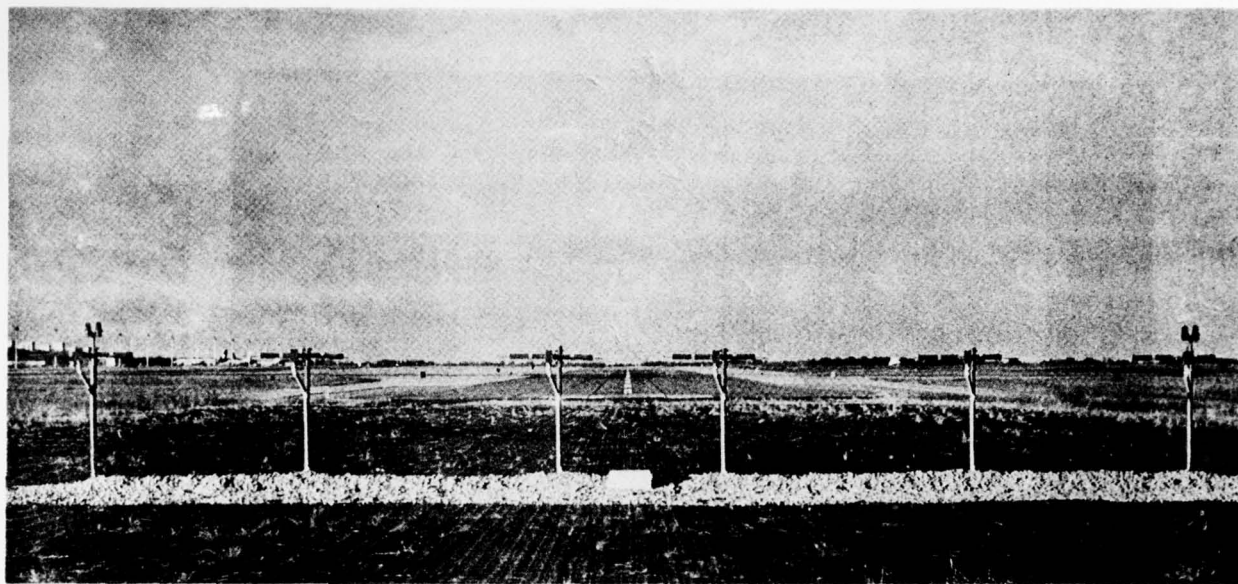
FIGURE Q 8



Log Periodic Dipole Localizer Antenna Array
Wilcox Model 1203 (6 Elements), Waukegan, Ill.

Photo Courtesy Wilcox Electric Incorporated

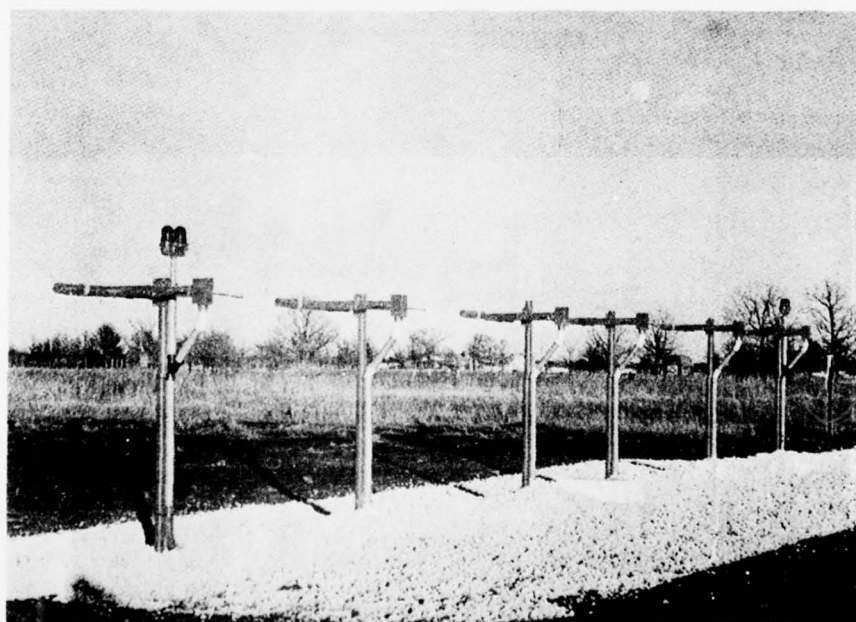
FIGURE Q 9



Log Periodic Dipole Localizer Antenna Array
Front View, Wilcox Model 1261 (6 Elements) Greenville, Tx.

Photo Courtesy Wilcox Electric Incorporated

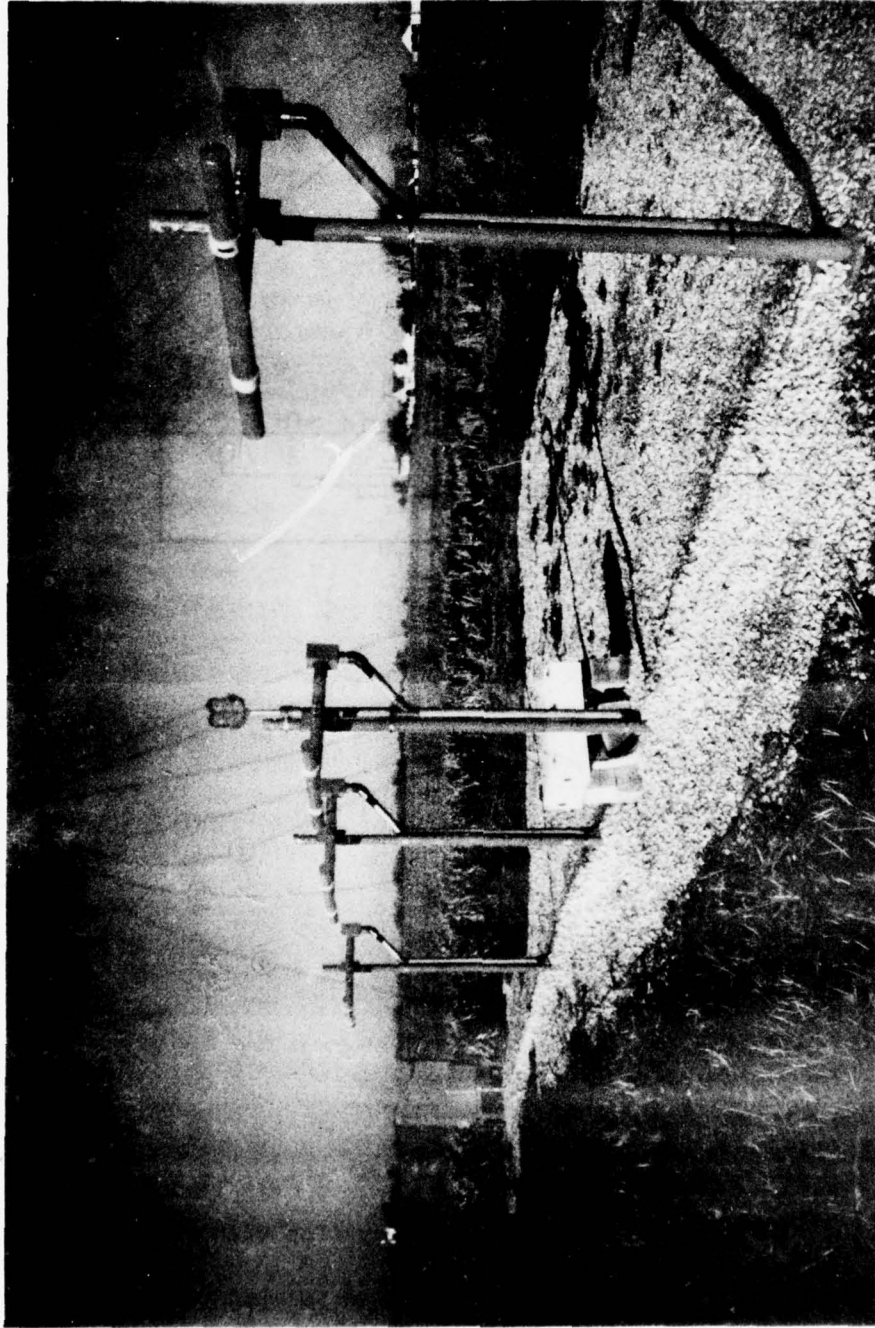
FIGURE Q 10



Log Periodic Dipole Localizer Antenna Array
Side View, Wilcox Model 1261 (6 Elements) Greenville, Tx.

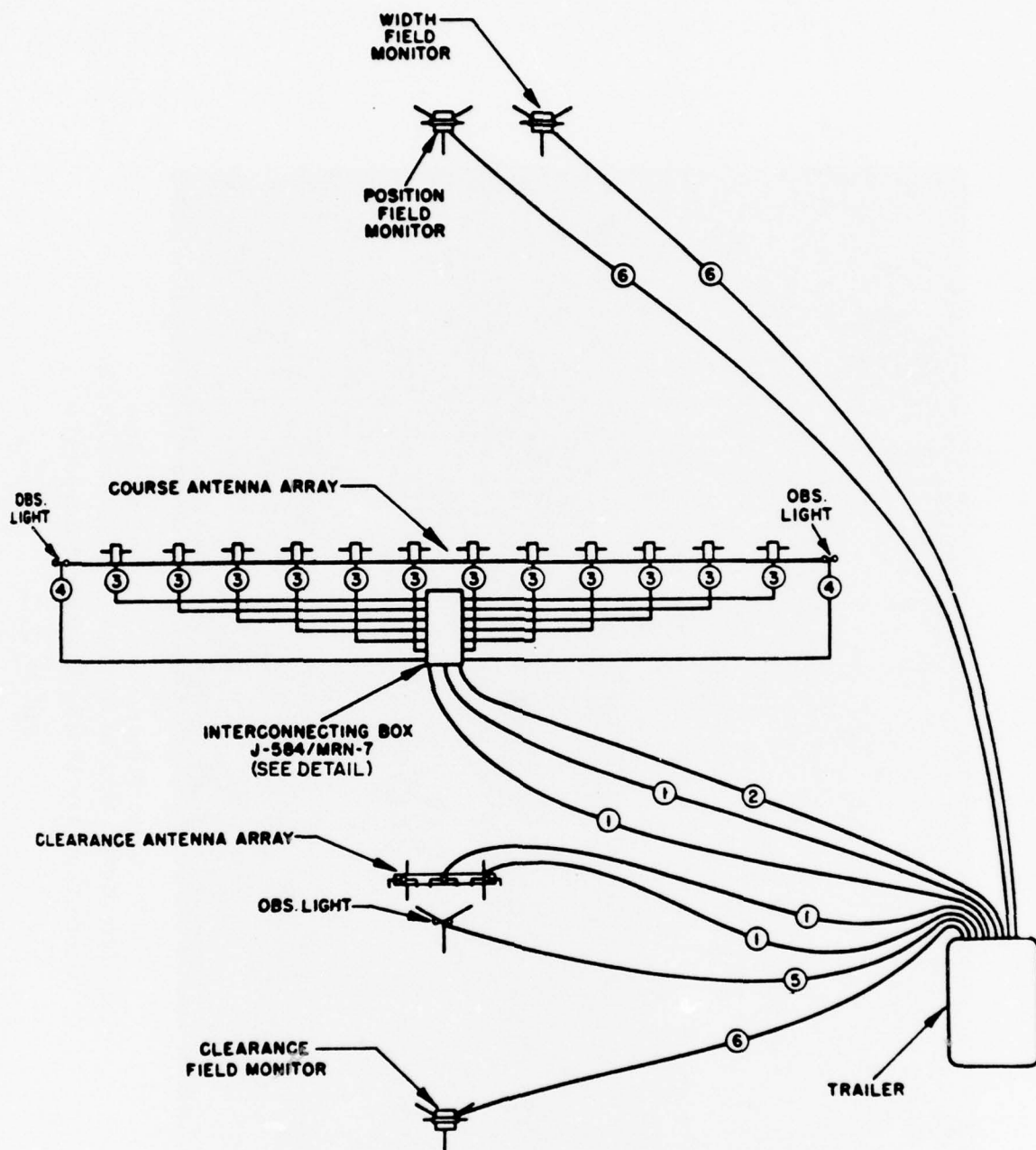
Photos Courtesy Wilcox Electric Incorporated

FIGURE Q 11



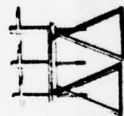
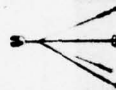
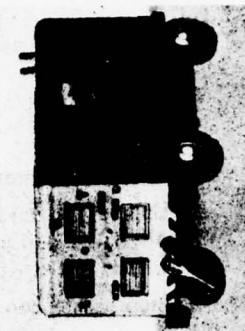
Log Periodic Dipole Localizer Antenna Array
Wilcox Model 1260 (4 Elements), Higginsville, Mo.
Photo Courtesy Wilcox Electric Incorporated

FIGURE Q 12



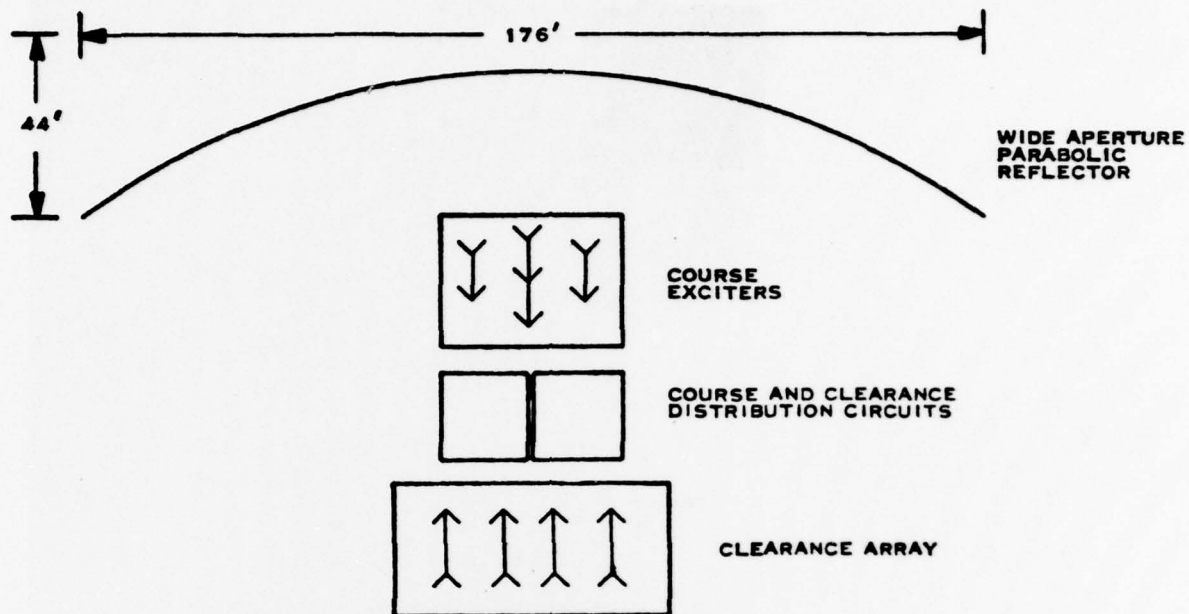
MRN-7 Localizer Antenna Array (Top View)

FIGURE Q 13



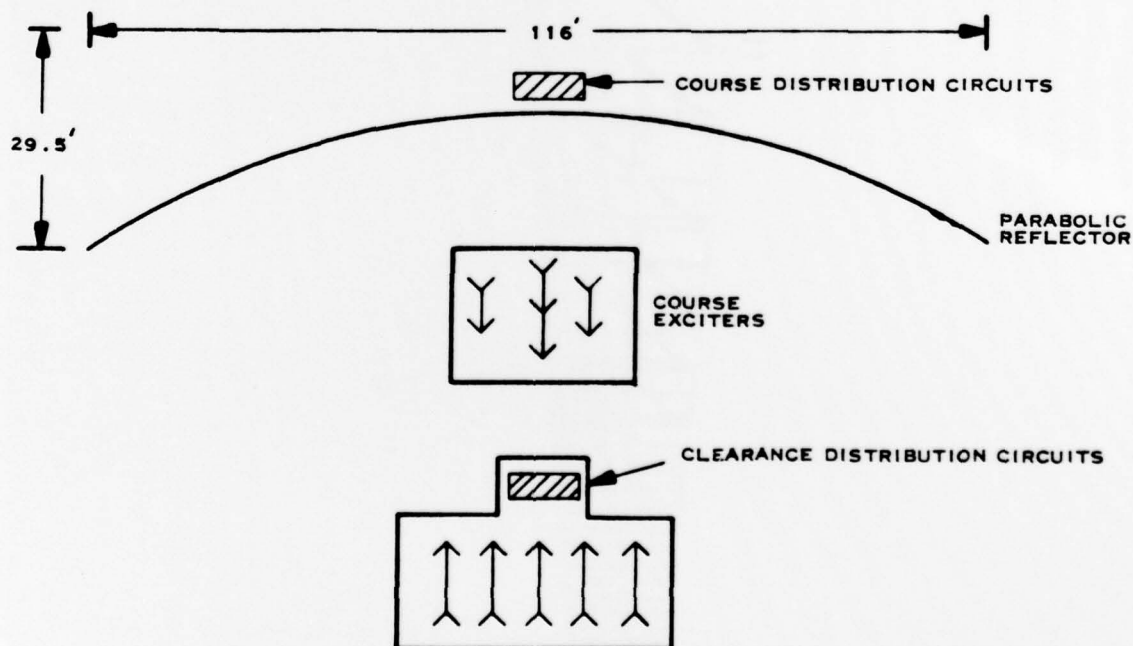
MRN-7 Antenna Array

FIGURE Q 14



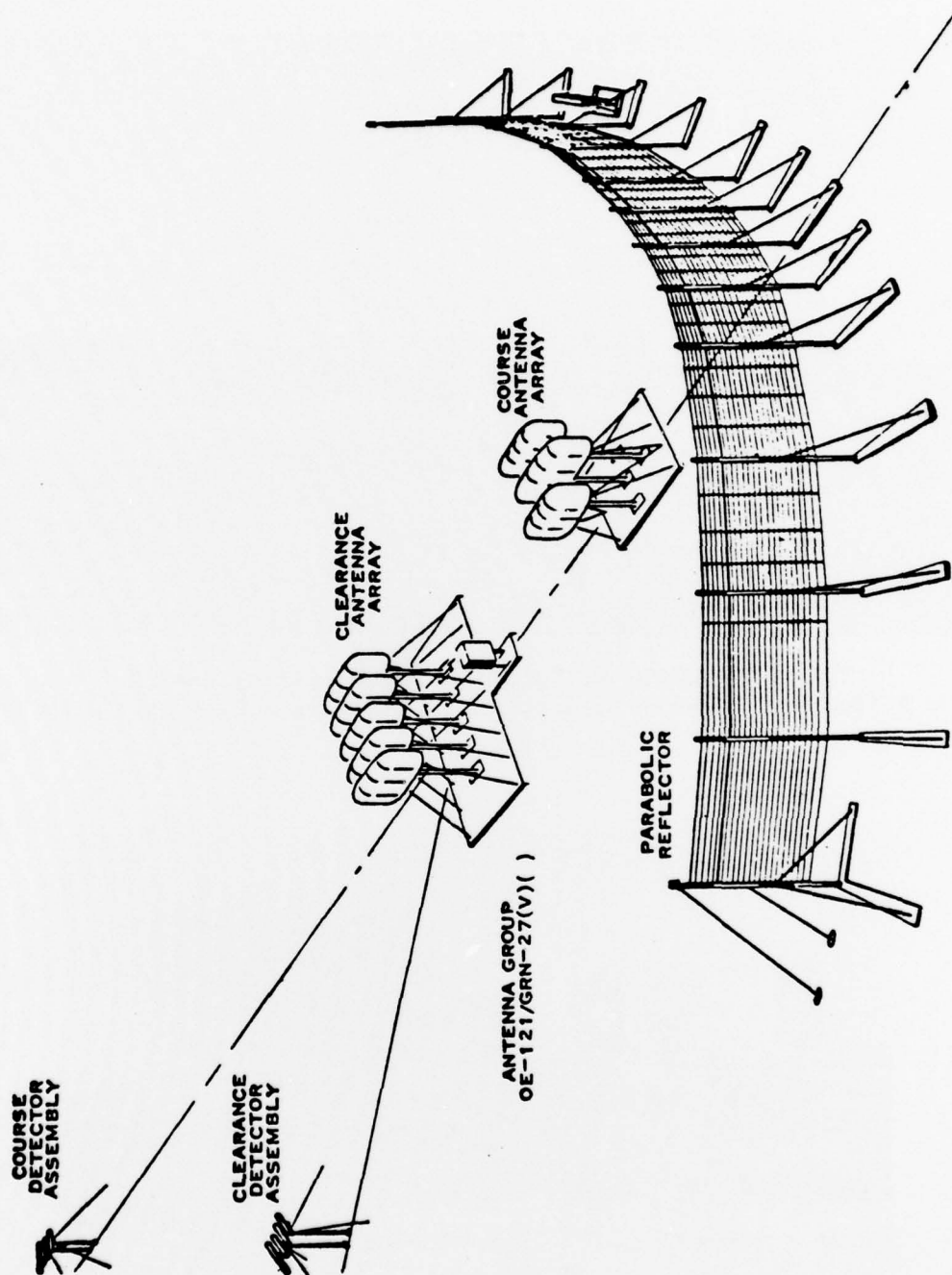
T.I. Wide Aperature Parabolic Array

FIGURE Q 15



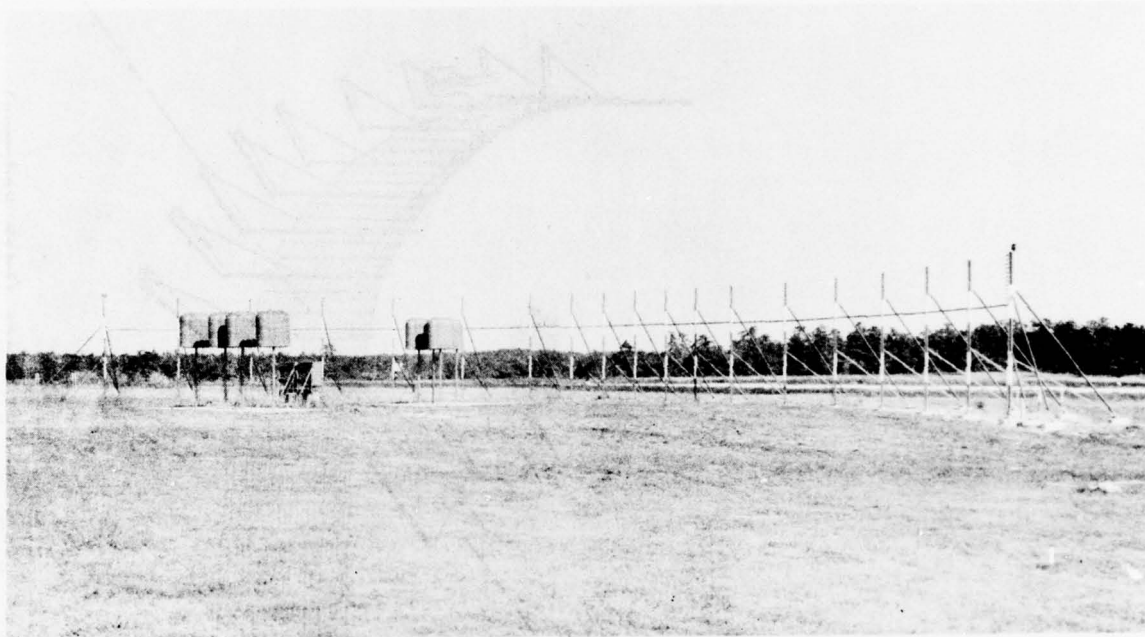
T.I. Narrow Aperature Parabolic Array

FIGURE Q 16



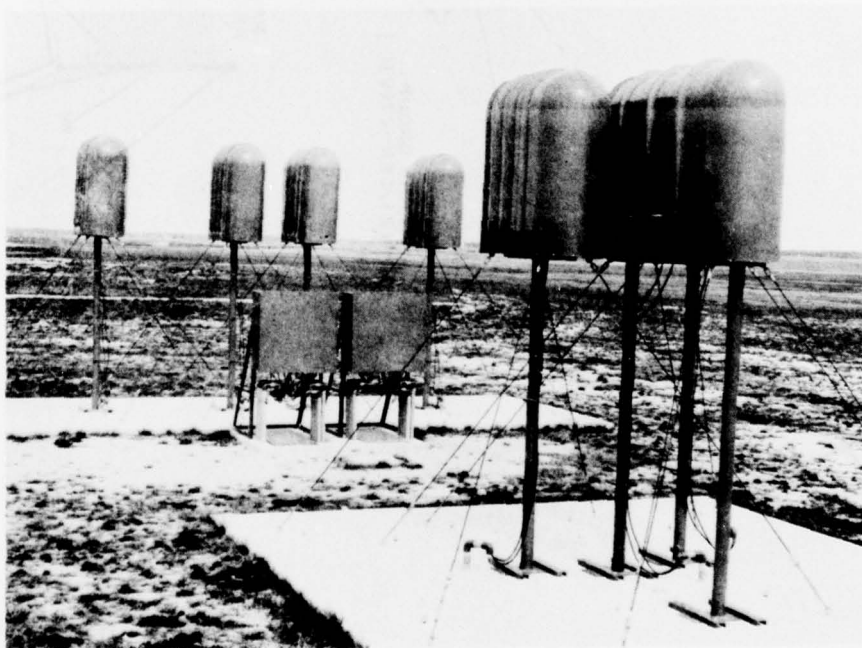
T.I. Narrow Aperature Parabolic Antenna Array
Parabolic Reflector, 3 Course Elements and 5 Clearance Elements (with Radomes)

FIGURE Q 17



T.I. Wide Aperature Parabolic Antenna Array, NAFEC
Parabolic Reflector, 3 Course Elements, and 4 Clearance Elements (with Radomes)

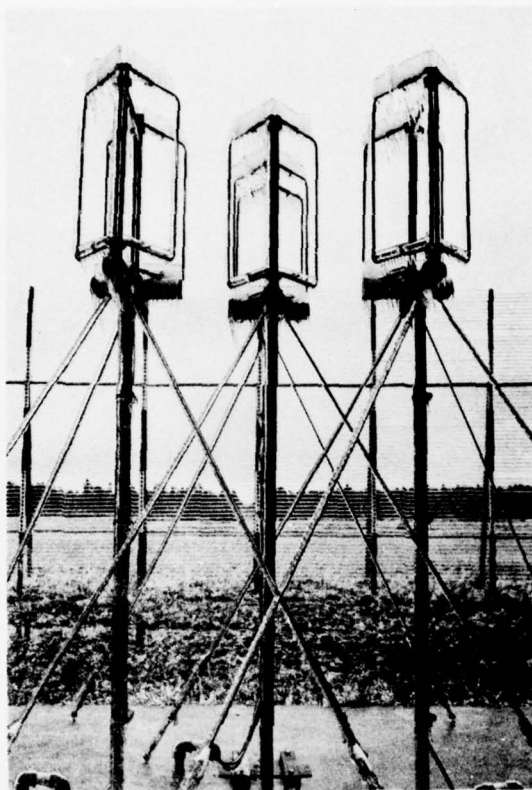
FIGURE Q 18



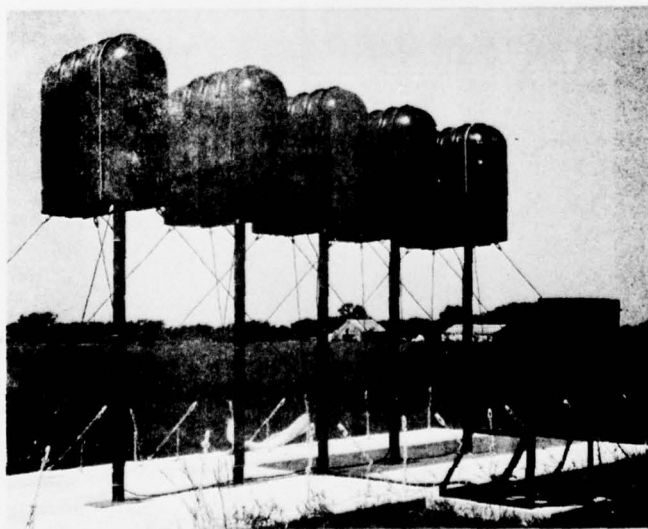
T.I. Wide Aperature Parabolic Antenna, NAFEC
3 Course Elements and 4 Clearance Elements (with Radomes)

FIGURE Q 19

Q 14

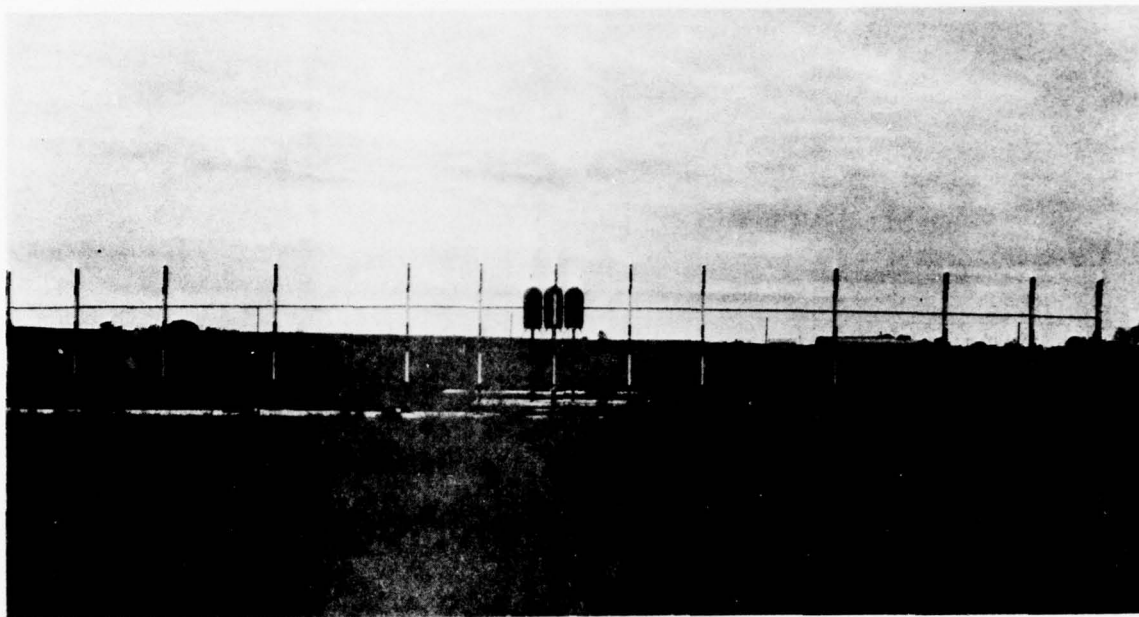


T.I. Wide Aperature Parabolic Antenna
5 Element Clearance Array (w/o Radomes)
FIGURE Q 20



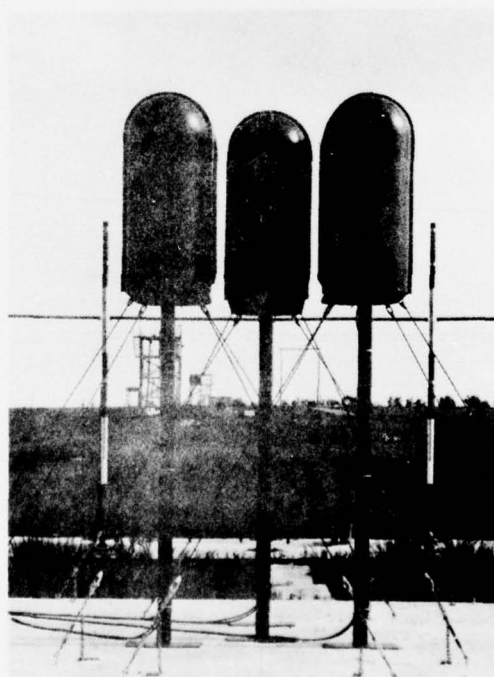
T.I. Narrow Aperature Parabolic Antenna
5 Element Clearance Array (with Radomes)
Photo Courtesy Texas Instruments Incorporated

FIGURE Q 21



T.I. Narrow Aperature Parabolic Antenna Array
 Parabolic Reflector and 3 Course Elements (with Radomes)
 Photo Courtesy Texas Instruments Incorporated

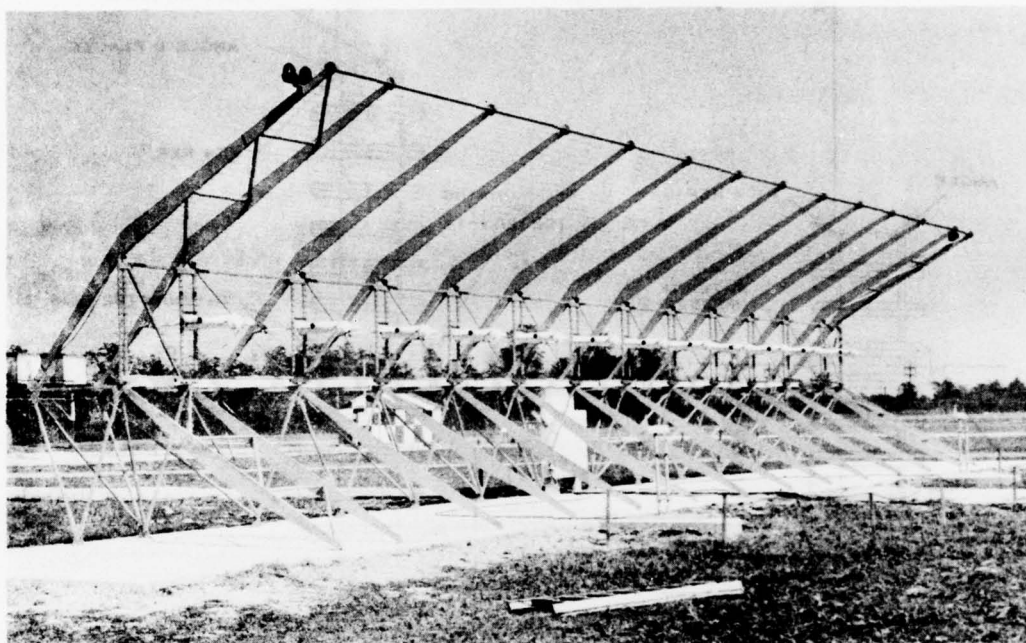
FIGURE Q 22



T.I. Narrow Aperature Parabolic Antenna
 3 Element Course Array (with Radomes)
 Photo Courtesy Texas Instruments Incorporated

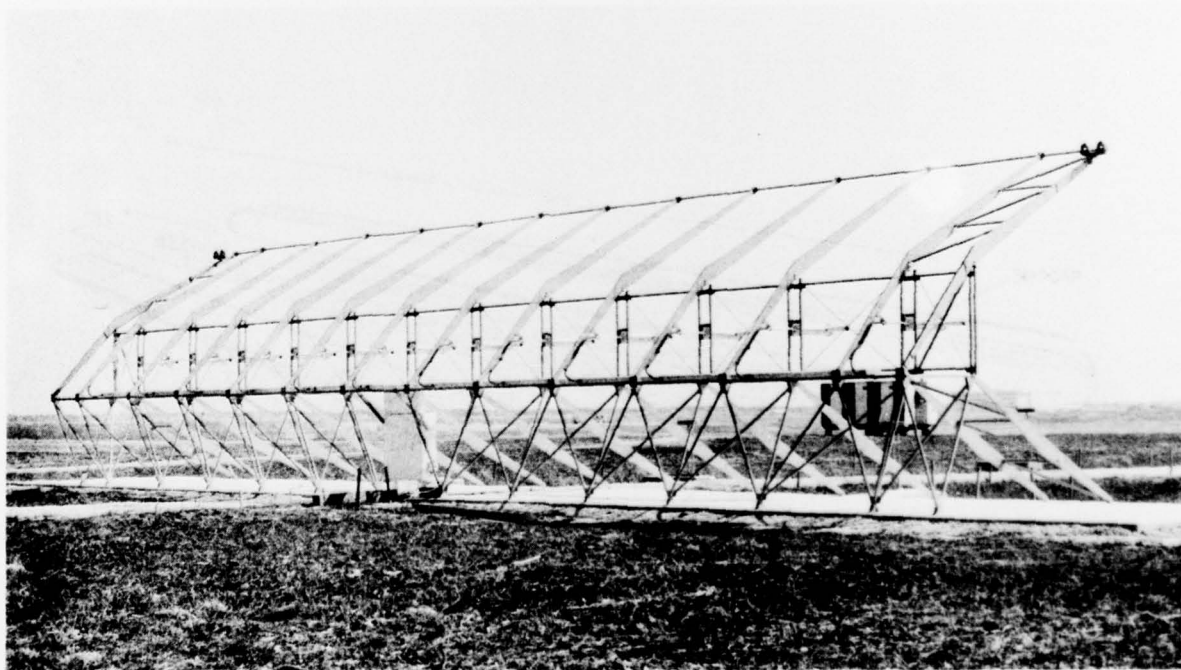
FIGURE Q 23

Q 16



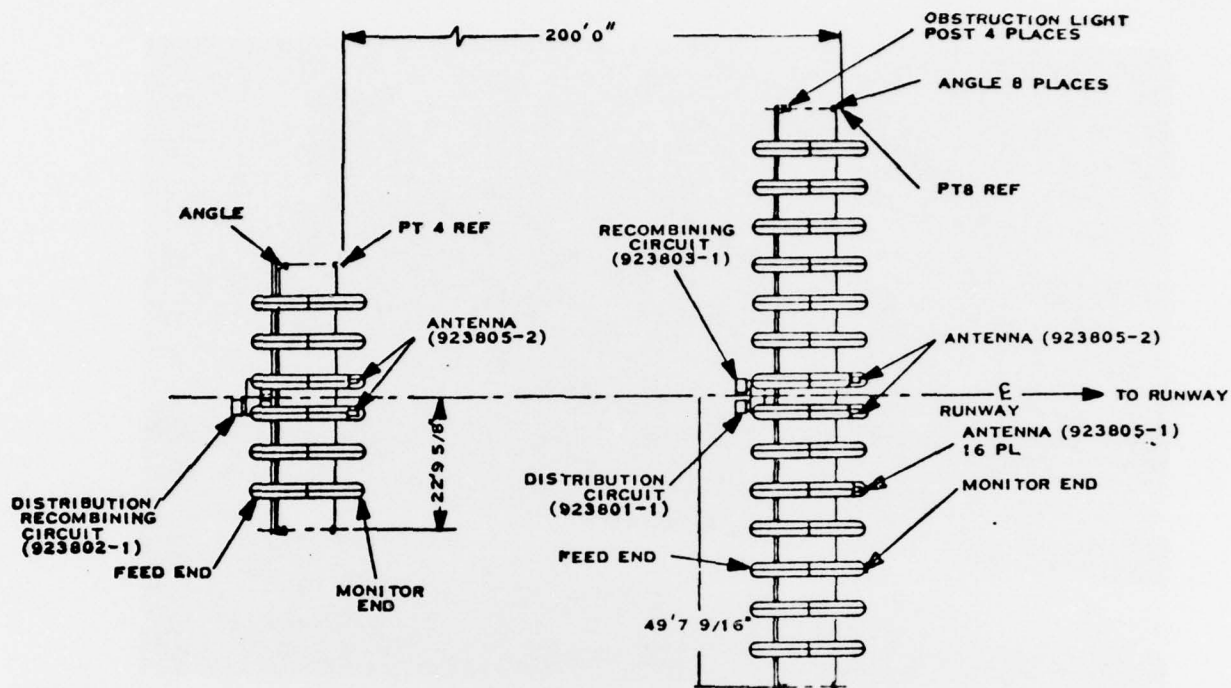
STAN-37 ILS Localizer Antenna Array
NAFEC, Front View (12 Elements)

FIGURE Q 24



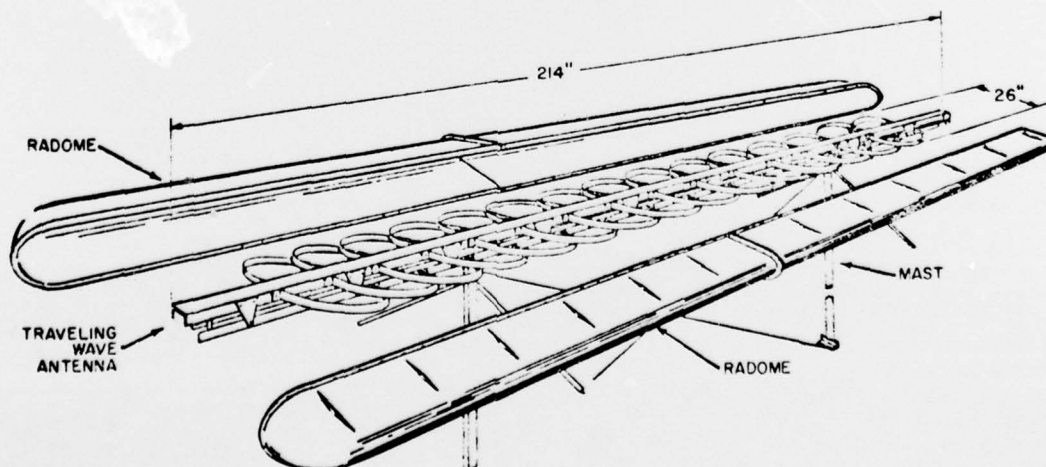
STAN-37 ILS Localizer Antenna Array
NAFEC, Back View (12 Elements)

FIGURE Q 25



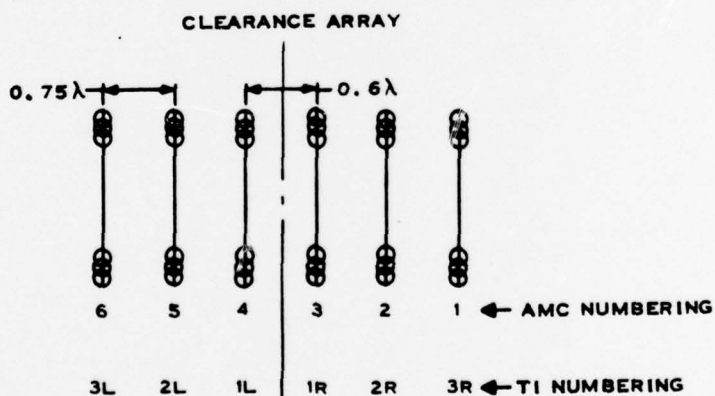
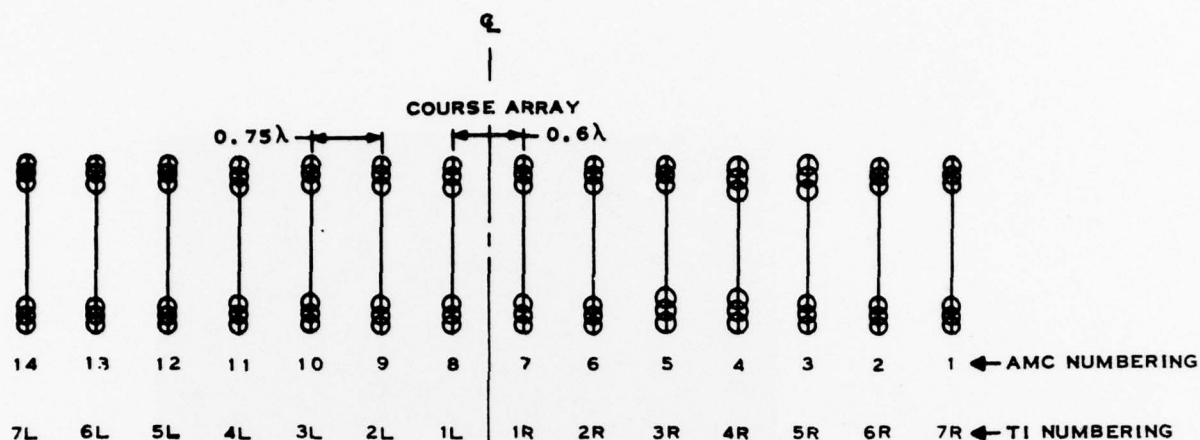
T.I. Traveling Wave Antenna Array (14/6)

Figure Q 26



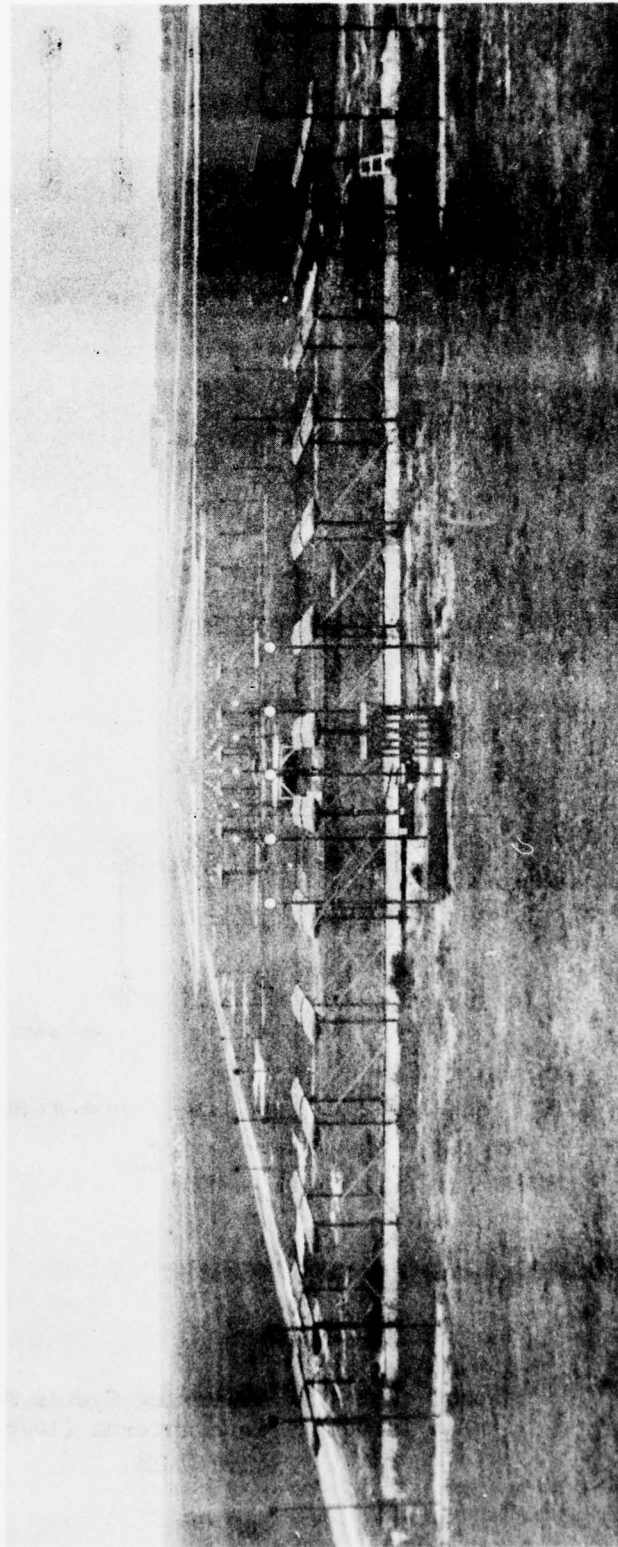
Single Traveling Wave Antenna Element

Figure Q 27



TO RUNWAY

A.M.C. And T.I. Numbering System For
The Traveling Wave Antenna (14/6)
Figure Q 28



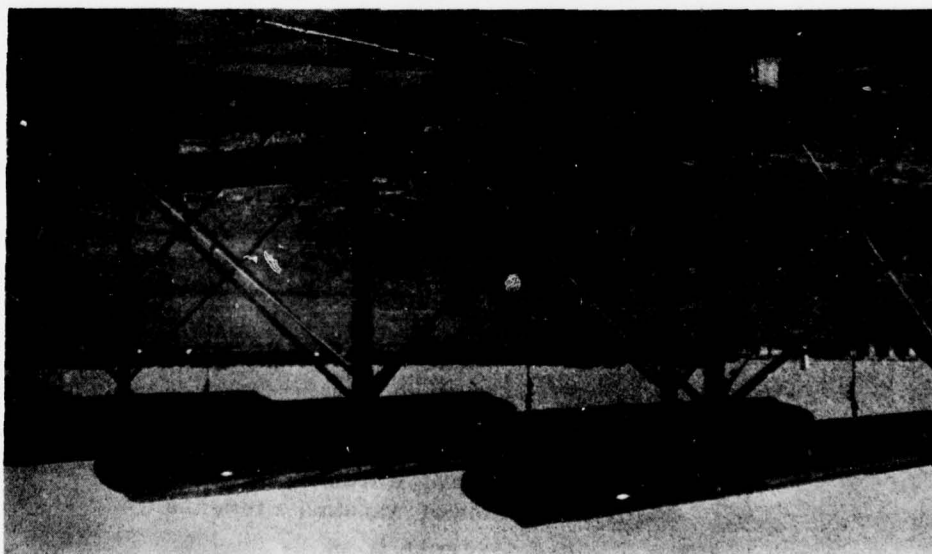
T.I. Traveling Wave Localizer Antenna Array With Radomes
(14 Course Elements, 6 Clearance Elements), NAFEC

Figure Q 29



Traveling Wave Localizer Antennas Without Radomes
Close Up of T.I. Antenna Elements

Figure Q 30



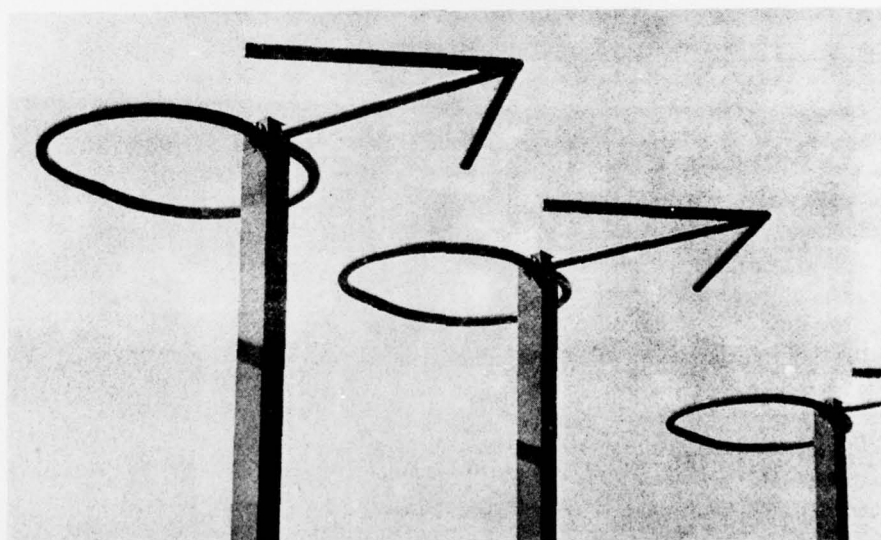
T.I. Traveling Wave Localizer Antennas With Radomes
Close Up Of T.I. Antenna Elements

Figure Q 31



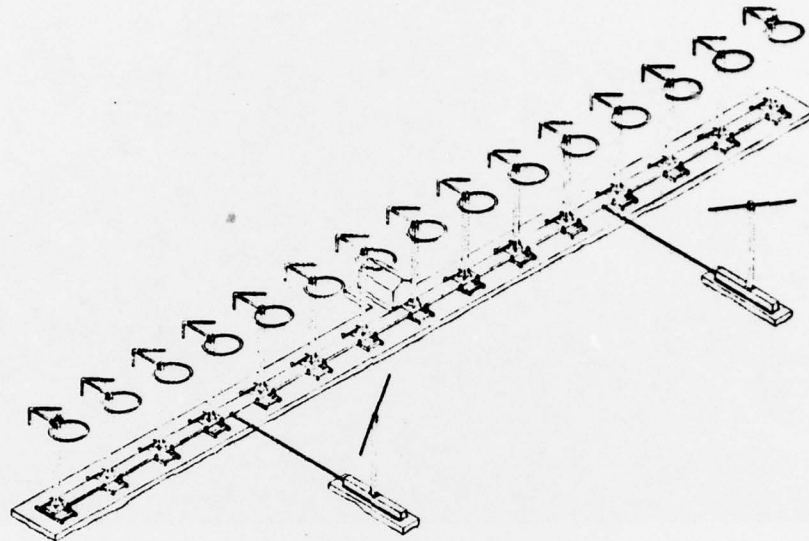
T.I. Traveling Wave Localizer Antenna Array
8 Element Self Clearing Array

Figure Q 32



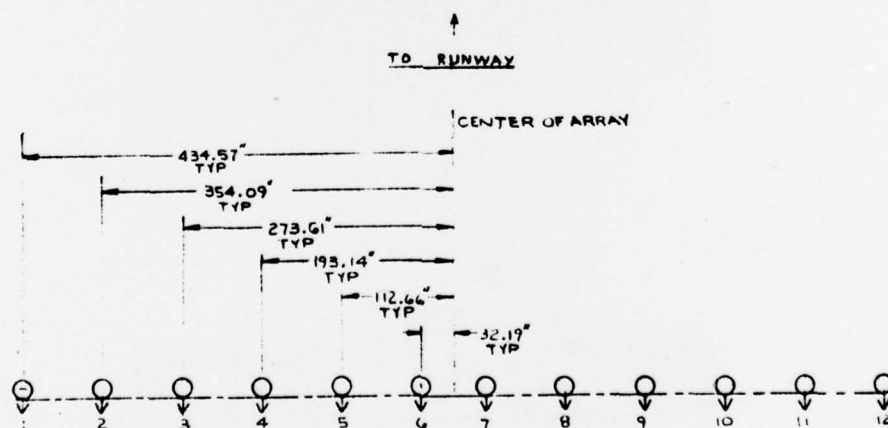
Standard V-Ring Antenna, NAFEC
Close Up View of Antenna Elements

Figure Q 33



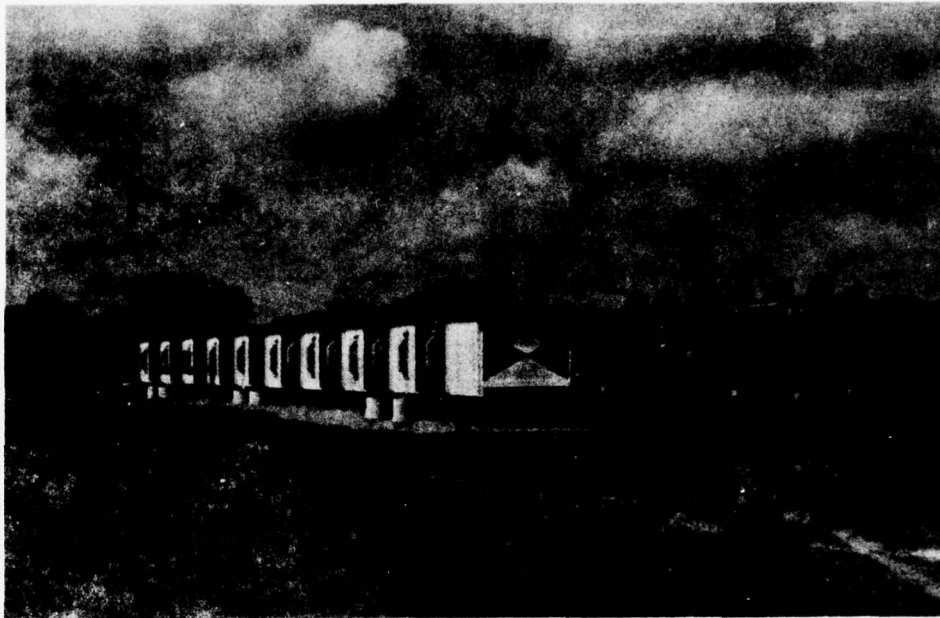
Standard 15 Element V-Ring
Localizer Antenna Array

Figure Q 34



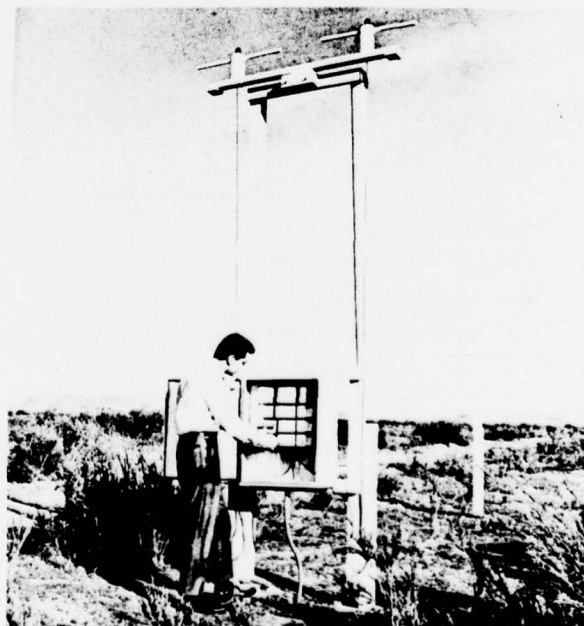
Antenna Spacing For The 12 Element
V-Ring Localizer Antenna Array

Figure Q 35



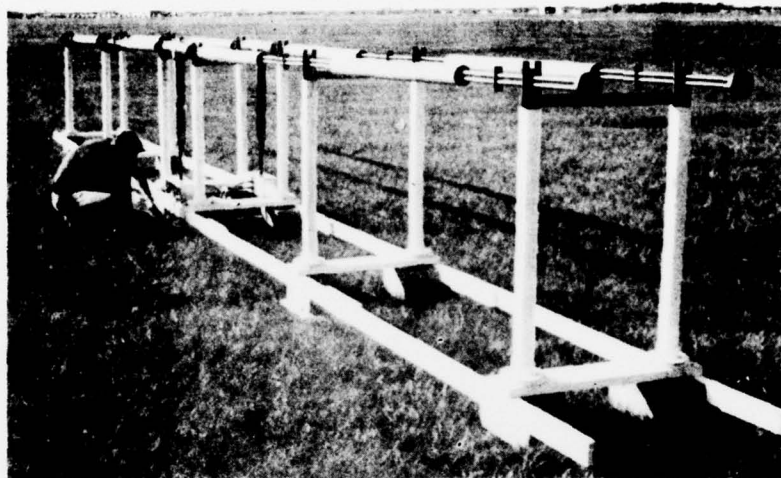
Waveguide Localizer Antenna Array
Waveguide Course Array (18 Elements) With A Standard
Eight Loop Clearance Array

Figure Q 36



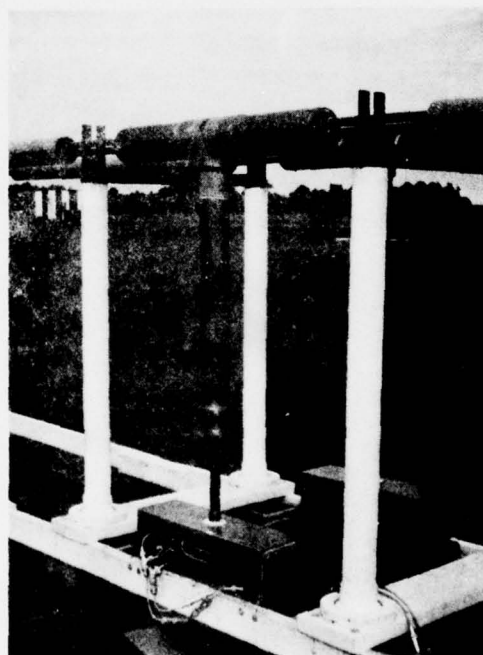
Cubic Corp. VORLOC II LDA Antenna

Figure Q 37



Slotted Cable Localizer Antenna Array
Experimental System, Full Array

Figure Q 38



Slotted Cable Localizer Antenna
Experiment System, Close Up

Figure Q 39